Record of Decision
Holden Mine Site
Chelan County, Washington

Prepared by
USDA Forest Service

In Cooperation with
US Environmental Protection Agency and
Washington State Department of Ecology

January, 2012
4769-16

RECORD OF DECISION

PARTS 1 & 2

THE HOLDEN MINE SITE
CHELAN COUNTY, WASHINGTON

JANUARY 2012

PREPARED BY
USDA FOREST SERVICE
WENATCHEE, WASHINGTON

IN COOPERATION WITH
US ENVIRONMENTAL PROTECTION AGENCY AND
THE WASHINGTON STATE DEPARTMENT OF ECOLOGY

PART 1 – DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Holden Mine is an inactive underground copper mine located in the Railroad Creek valley in Chelan County on the eastern slopes of the Cascade Mountains in Washington State. The mine is located approximately 9 miles west of Lake Chelan and lies within the Okanogan-Wenatchee National Forest except for about 235 acres of patented mining claims owned by Holden Village (see Figure D-1 following this Declaration; tables and additional figures are presented following the main text).

The Holden Mine Site (Site) includes the entire area impacted by releases of hazardous substances from the mine. The mine was formerly operated by the Howe Sound Company.

The former miners' town, Holden Village, is located on National Forest System lands adjacent to the mine and is now occupied by Holden Village, a non-profit Lutheran ministry and community. Holden Village operates under a Special Use Permit with the Forest Service. Holden Village is home to about 60 year-round residents and hosts approximately 5,000 visitors per year.

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) selects the remedy for cleanup of the Holden Mine Site. The United States Department of Agriculture Forest Service (Forest Service) and the United States Environmental Protection Agency (EPA) are issuing this ROD under the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Section 117(b), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. § 300.430(f)(4). The State of Washington concurs with the Selected Remedy as it satisfies the Washington State Department of Ecology's (Ecology) criteria for selecting a cleanup action under the Model Toxics Control Act (MTCA), Chapter 70.105D RCW and Chapter 173-340 WAC. This decision is based on the Administrative Record for the Site, which is summarized within this ROD.

The Forest Service serves as the lead agency, in cooperation with the EPA and Ecology, for the management of site activities and preparation of this ROD. The Forest Service, Ecology, and EPA (jointly referred to as the Agencies) selected a remedy for the Site after reviewing and considering the information submitted

during the public comment period. The Agencies coordinated with the Confederated Tribes and Bands of the Yakama Nation on remedy selection.

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health or welfare, or the environment, from actual or threatened releases of hazardous substances into the environment. Such a release or threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF SELECTED REMEDY

Overall Cleanup Strategy

This ROD selects a final remedy for the Site. The selected remedy will address the ongoing release of significant contamination from past mining activities including acid mine drainage and releases from tailings and waste rock piles. Hazardous substances from these sources have impacted aquatic life in Railroad Creek, and present unacceptable risks to human health and the environment.

Acid mine drainage (AMD), runoff from the tailings and waste rock piles, and groundwater impacted by leaching from the tailings and waste rock piles (acid rock drainage [ARD]) continue to release hazardous substances that result in substantial adverse effects on groundwater and surface water quality. Surface water in Railroad Creek has concentrations of hazardous substances above aquatic life protection criteria over a distance of 10 miles downstream of the mine. Vegetation is visibly distressed in the wetlands east of Tailings Pile 3, in the area impacted by runoff and shallow groundwater seepage from the tailings pile. Concentrations of contaminants in seeps flowing into the creek are up to several orders of magnitude above cleanup levels.

The overall cleanup strategy is to prevent releases of hazardous substances to surface water by containment, collection, and treatment of impacted groundwater, as well as by preventing the future release of tailings into the creek. Drainage from the mine will be collected and treated to remove hazardous substances, then discharged into Railroad Creek. A fully penetrating barrier wall will be constructed around the tailings piles to contain and collect contaminated groundwater, which will be conveyed to a treatment facility.

Humans and terrestrial ecological receptors will be protected by consolidating and capping the tailings and soil impacted by the tailings, as well as most of the waste rock. Some areas of impacted soil and waste rock located on steep slopes and in areas that have significant habitat value, but which cannot be consolidated or capped without severe adverse effects on this habitat, will be remediated by *in situ* treatment to reduce the mobility and bioavailability of the hazardous substances. Uncontaminated surface water run-on will be diverted around the waste rock and tailings piles to reduce the need for water treatment. Ongoing groundwater, surface water, and biota monitoring will measure the success of different remedial components. The Site's remote location affects the feasibility of the alternatives considered.

Containment is a viable remedy for this Site, since no Principal Threat Wastes (i.e., those sources of materials that are considered to be highly toxic or highly mobile that generally cannot be reliably contained, or that present a significant risk to health or the environment should exposure occur) are present at the Site.

Major Components of the Selected Remedy

The major components of the Selected Remedy for the Site are more fully described below. Refer to Figure D-1 for locations of site features.

Groundwater Containment, Collection, and Treatment

Groundwater that drains from the mine, AMD, will be contained by three hydraulic barriers (bulkheads) in the 1500 Level Main Portal, the 1500 Level Ventilator Portal, and the 1100 Level adit. The 1500 Level bulkheads will release groundwater from the mine in a controlled manner so that it can be conveyed by pipeline to a groundwater treatment facility (treatment facility).

A below-grade groundwater barrier wall will be constructed on the downgradient side of Tailings Pile 1 and the adjoining Lower West Area to contain and collect impacted groundwater. A second groundwater barrier wall and collection system will be located downgradient of Tailings Piles 2 and 3. Construction of groundwater containment around the tailings piles is necessary to prevent further migration of contaminants in groundwater and to protect downgradient surface water. Because of this containment, the areas within the barrier wall are designated as Waste Management Areas (WMAs).

Containment and treatment of groundwater from the WMAs will address the effects of ARD at and beyond the WMA boundaries and enable restoration of

groundwater quality outside the WMAs. The selected remedy establishes two WMAs, with the Lower West Area (including Tailings Pile 1 and the main waste rock piles) as one WMA, and Tailings Piles 2 and 3 as a second WMA, with a groundwater point of compliance (POC) associated with each. Groundwater will comply with drinking water standards (MCLs) at and beyond the edge of the WMAs in accordance with the NCP preamble language which sets forth "EPA's policy that for groundwater, "remediation levels should generally be attained throughout the contaminated plume, or at and beyond the edge of the waste management area when waste is left in place" (55 Fed. Reg. 8713). Groundwater flow from seeps downgradient of the Honeymoon Heights Waste Rock Piles that exceeds water quality criteria will also be collected and conveyed by pipe to the treatment facility.

Groundwater discharging to surface water must also meet surface water cleanup standards at a POC before the groundwater-surface water interface[1]. Groundwater cleanup levels protective of surface water must be achieved before the portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates to be protective of aquatic life, and not simply in the surface water column after dilution has occurred.

The collected groundwater will be treated by pH adjustment and oxidation to convert dissolved metals into metal hydroxides that will precipitate in the treatment facility ponds and will later be disposed of in an on-site landfill.

Consolidation and Capping of Tailings, Waste Rock, and Impacted Soil

The tailings piles and the main waste rock piles will be regraded to improve slope stability, to improve precipitation runoff, and to reduce infiltration. Impacted soil will be removed from several areas of the Site and consolidated into the tailings piles. Stormwater diversion swales will be constructed upgradient of the tailings piles and the main waste rock piles to reduce surface water run-on and infiltration. The tailings and main waste rock piles will be capped with soil and/or other materials designed to contain the tailings and waste rock, reduce exposure to the environment, and eliminate unacceptable

[1] For Ecology's purposes on behalf of the State of Washington, this point is also a conditional POC under MTCA, WAC 173-340-720(8)(c).

risk to terrestrial plants and animals. Native vegetation will be established on the caps to provide long-term erosion resistance and terrestrial habitat.

In situ Remediation

Soil will be treated by *in situ* application of agricultural lime in areas of the Site where soil excavation or capping is not feasible (such as steep slope areas) or where excavation or capping will cause more severe adverse impacts than the existing hazardous substances (e.g., in the Honeymoon Heights waste rock piles and the area downslope of these piles). This *in situ* treatment will adjust pH and thereby reduce bioavailability and mobility of hazardous substances in areas where critical and sensitive habitat limit or preclude more intrusive actions. This includes the areas downslope of Honeymoon Heights (DSHH) waste rock piles, and areas of late succession riparian habitat (primarily in the Lower West Area). In Holden Village, *in situ* treatment is an alternative remediation measure that would avoid disrupting existing structures and utilities.

Surface Water

In addition to the measures described above that will prevent the release of hazardous substances into surface water, the Selected Remedy includes relocation of a portion of Railroad Creek to eliminate the effects of ferricrete (formed from hazardous substances entering the creek) on aquatic receptors, and to prevent instability of the tailings pile slopes from erosion and scour. The extent of creek relocation will be determined during remedial design, since it affects the extent of tailings regrading that will be required to assure stability of the tailings pile slopes, and to enable construction of the groundwater barrier walls and collection system. The new channel will have an impervious lining where needed to prevent infiltration of clean water into contaminated groundwater that will be collected adjacent to the tailings piles.

Institutional Controls

The Selected Remedy also includes institutional controls that will:

- Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;

- Protect the integrity of the remedy by preventing changes in Site use that would reduce effectiveness of the remedy;

- Include a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective;

- Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;

- Prevent the potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;

- Provide for permanent access to privately owned land to monitor and maintain the remedy; and

- Implement possible administrative access restrictions to some portions of the Site.

The Forest Service will implement institutional controls on National Forest System land through the notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest. Institutional controls will be implemented on private property owned by Holden Village through a restrictive covenant.

Sediment

The Selected Remedy includes relocation of a portion of Railroad Creek, which will eliminate the adverse effects of ferricrete on the aquatic habitat. Also the wetland east of Tailings Pile 3 will be remediated or replaced depending on whether the groundwater treatment system is located there.[2] This wetland has been adversely impacted by runoff and sedimentation (as well as shallow groundwater impacted by leaching of the tailings) from the adjacent tailings pile. The Agencies have determined that other active measures to clean up sediment are not warranted at this time as discussed in the final Feasibility Study (see Section 4.1.1.3.4 of the SFS). Rather, the remedy will include source controls and relocation of a portion of Railroad Creek to prevent ongoing release of hazardous substances into Railroad Creek. Long-term monitoring will determine if the remedy is protective of sediment quality.

[2] In addition, mitigation will also be required in accordance with Section 404 of the Clean Water Act.

Phased Approach to Remedy Implementation

The Selected Remedy will require several years of construction to implement. The potentially responsible party, Intalco Aluminum Corporation, has proposed and is implementing some early actions to prepare for the larger scale cleanup efforts. These early actions may include remedial design, baseline monitoring, and some construction work such as dock and road improvements; development of quarry, borrow, and staging areas; and construction of hydraulic bulkheads in the mine. The scope, schedule, and details of these early actions are subject to oversight by the Agencies under 2010 and 2011 amendments to an Administrative Order on Consent (AOC).

The Agencies have determined it is beneficial to construct the remedy in two phases, solely to reduce the adverse effects of construction on Holden Village.

- The first phase of the remedy will include relocation of Railroad Creek, construction of the treatment facility, regrading and capping the tailings piles and the main waste rock piles, beginning the *in situ* soil treatment, and construction of the groundwater barrier and collection system downgradient of Tailings Pile 1 and the Lower West Area.

- The second and final phase of the remedy will include construction of the groundwater barrier and collection system downgradient of Tailings Piles 2 and 3. The second phase of construction will begin 5 years after completion of the first phase.

Intalco proposes to monitor the effects of the first phase of the remedy to determine whether results of the first phase support modifying the second phase. Intalco has stated, but has not demonstrated, that construction of the second groundwater barrier wall and collection system will be unnecessary once the first phase of the remedy is completed. Currently there is no evidence that without the additional barrier wall, cleanup levels based on protection of surface water (i.e., the aquatic life criteria, because they are lower than the drinking water criteria) will be met in groundwater before the groundwater discharges into surface water downstream of Tailings Piles 2 and 3. Moreover, without containment, there would not be a WMA and MCLs would need to be met throughout the Site, including under Tailings Piles 2 and 3, or there would need to be an applicable or relevant and appropriate requirement (ARAR) waiver for MCLs based on technical impracticability from an engineering perspective, which, if justified, would require a ROD Amendment. Such an ARAR waiver would not be approved unless the remedy was shown to be protective,

including the protection of aquatic life where groundwater discharges to surface water, and the establishment of institutional controls to prevent use of groundwater for drinking water below the tailings piles.

The period between the first and second phase presents an opportunity for Intalco to collect data in an effort to support a proposal to modify the second phase. The ROD allows for the collection of additional data following implementation of the first phase cleanup components and includes the provision that the barrier wall design could be modified or would not need to be installed, if demonstrated to satisfy ARARs and be protective within a timeframe comparable to the Selected Remedy. The second phase of the remedy would not need to be installed only if it can be demonstrated to the Agencies' satisfaction that:

1. Groundwater concentrations are reduced to achieve surface water cleanup levels before that portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates; and

2. One of the following: a) groundwater meets MCLs below Tailings Piles 2 and 3, as well as throughout the plume; or b) groundwater that exceeds drinking water standards will be contained within a WMA; or c) an ARAR waiver for MCLs beneath Tailings Piles 2 and 3 based on technical impracticability from an engineering perspective is justified.

Such a change would require a ROD Amendment. The basis for the change must be demonstrated within three years of substantial completion of the first phase of remedial construction, so that a decision can be made in the fourth year. Unless the second phase groundwater barrier and collection system is eliminated, the second phase of remedial action is expected to be designed in the fifth year and constructed immediately thereafter.

STATUTORY DETERMINATIONS

The Selected Remedy attains the mandates of Section 121 of CERCLA, 42 U.S.C. § 9621 and, to the extent practicable, the NCP, 40 C.F.R. Part 300. The Selected Remedy will:

- Be protective of human health and the environment;

- Comply with applicable or relevant and appropriate requirements (ARARs), unless a waiver is justified;

- Be cost-effective;

- Use permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable; and

- Satisfy the statutory preference for treatment as a principal element of the remedy (i.e., which permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances as a principal element through treatment).

After the Selected Remedy is implemented, hazardous substances that exceed levels that allow unlimited use and unrestricted exposure will remain on the Site. Statutory reviews will be conducted at least every 5 years after the remedial action begins to ensure that the Selected Remedy is, or will be, protective of human health and the environment.

DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary (Part 2) of this ROD. More information is available in the Administrative Record for the Site.

- Contaminants of concern (COCs) and their respective concentrations. (See Section 5.3.1)

- Baseline risk represented by the COCs. (See Sections 7.1 and 7.2)

- Cleanup levels established for the COCs and the basis for the levels. (See Section 7)

- Whether source materials constituting Principal Threat Wastes are present at the Site. (See Section 11)

- Current and reasonably anticipated future land uses and current and potential future groundwater use assumptions used in the baseline risk assessment and ROD. (See Section 6)

- Potential land and groundwater use that will be available at the Site as a result of the Selected Remedy. (See Section 12.3)

- Estimated capital, annual operation and maintenance (O&M), and total present worth costs of the remedy, including the discount rate used and the number of years over which the remedy cost estimate is projected. (See Section 12.1)

- Key factors that led to selecting the remedy. (See Section 10)

AUTHORIZING SIGNATURES FOR THE RECORD OF DECISION FOR THE HOLDEN MINE SITE (Sheet 1 of 3)

United States Department of Agriculture
Forest Service Region 6
By: _____ 1/26/12
for Kent P. Connaughton — Date
Regional Forester

AUTHORIZING SIGNATURES FOR THE RECORD OF DECISION FOR THE HOLDEN MINE SITE (Sheet 2 of 3)

U.S. Environmental Protection Agency

By: _____ 1/27/2012

Daniel D. Opalski — Date

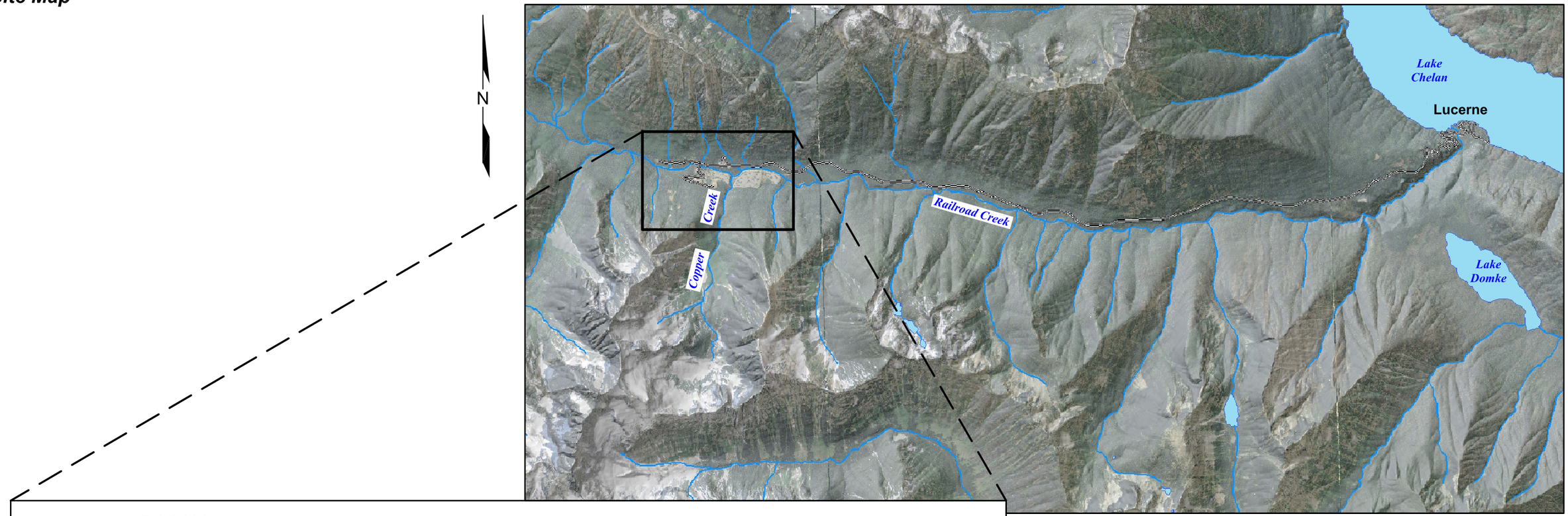
Director, Office of Environmental Cleanup, Region 10

AUTHORIZING SIGNATURE FOR ADOPTION OF THE RECORD OF DECISION FOR THE HOLDEN MINE SITE AS A CLEANUP ACTION PLAN UNDER WAC 173-340-380(4) (Sheet 3 of 3)

Washington State Department of Ecology
By: _____
James J. Pendowski
Program Manager, Toxics Cleanup Program

1/26/12
Date

Site Map



EAL 12/22/11 476916ROD-016.dwg

Holden Mine Features

HARTCROWSER

4769-16 *12/11*

Figure D-1

ROD

CONTENTS Page

CONTENTS (Continued)

CONTENTS (Continued)

TABLES

Tables are located following the main text (except where noted).

CONTENTS (Continued)

TABLES (Continued)

FIGURES

Figures are located following Tables after the main text.

CONTENTS (Continued) Page

LIST OF ACRONYMS AND ABBREVIATIONS

AHPA	Archaeological and Historic Preservation Act
AKART	all known, available, and reasonable methods of treatment
asl	above sea level (referring to elevation)
AMD	acid mine drainage
AOC	Administrative Order on Consent
AOI	area of interest
APR	Agencies Proposed Remedy
ARARs	applicable or relevant and appropriate requirements
ARD	acid rock drainage
ASFS	Addendum to the Supplemental Feasibility Study
BO	Biological Opinion
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
COC	contaminant of concern
COPC	contaminant of potential concern
CRP	community relations plan
CWA	Clean Water Act
CUL	cleanup level
DFRI	Draft Final Remedial Investigation
DFS	Draft Feasibility Study
DFFS	Draft Final Feasibility Study
DRI	Draft Remedial Investigation
DSHH	areas downslope from Honeymoon Heights Waste Rock Piles
DOS	Dam Safety Officer
EC	environmental checklist (i.e., the SEPA checklist that was issued with the Proposed Plan)
Ecology	Washington State Department of Ecology
Eco-SSL	Ecological Soil Screening Level
EIS	Environmental Impact Statement
EISC	Environmental Indicator Soil Concentrations
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ESD	Explanation of Significant Differences
Forest Service	United States Department of Agriculture, Forest Service
FS	Feasibility Study
gpm	gallons per minute
FSQV	freshwater sediment quality value
HHRA	human health risk assessment
HQ	hazard quotient

LBI	Lutheran Bible Institute
L&I	Labor and Industries (Washington Department of)
LOAEL	lowest observed adverse effects level
LRMP	Land and Resource Management Plan
LWA	Lower West Area
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/kg	milligrams per kilogram
MSHA	Mine Safety and Health Administration
MTCA	Model Toxics Control Act
MWFP	Pacific Northwest Forest Plan
NCP	National Oil and Hazardous Substances Contingency Plan
NFMA	National Forest Management Act
NHPA	National Historic Preservation Act
NOAEL	no observed adverse effects level
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NRRB	National Remedy Review Board
NTR	National Toxics Rule
NWQC or NRWQC	National Recommended Water Quality Criteria
O&M	operation and maintenance
OMM	operations, maintenance, and monitoring (costs)
OSHA	Occupational Safety and Health Administration
POC	point of compliance
PRPs	potentially responsible party
RAO	remedial action objective
RBCs	risk-based concentrations
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remediation Project Manager
SEPA	State Environmental Policy Act
SFS	Supplemental Feasibility Study
SRA	surface water retention area
TBC	to be considered (criteria)
TEE	Terrestrial Ecological Evaluation
TRVs	Toxicity Reference Values
UAO	Unilateral Administrative Order
UCL	upper confidence limit
ug/L	micrograms per liter

U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WER	Water Effects Ratio
WMA	Waste Management Area
WSDFW	Washington State Department of Fish & Wildlife

PART 2 – DECISION SUMMARY

1.0 SITE NAME, LOCATION, AND DESCRIPTION

Holden Mine is an inactive underground copper mine located in the Railroad Creek valley on the eastern slopes of the Cascade Mountains in Chelan County, Washington State. The mine, formerly operated by the Howe Sound Company, is located approximately 9 miles west of Lake Chelan and lies mostly within the Okanogan-Wenatchee National Forest. The mine is located in the Railroad Creek Watershed that drains to Lake Chelan (Figures 1 and 2).

The mine is very remote. It is only accessible by passenger ferryboat service, commercial barge service, private boat, and/or floatplane from Chelan, Washington, up Lake Chelan to Lucerne. At Lucerne, at the mouth of Railroad Creek, a climbing, winding gravel road is the only route for vehicles to access the mine. The Glacier Peak Wilderness Area abuts the mine on three sides. The former miners' town, Holden Village, is located on National Forest System lands adjacent to the mine and is now occupied by a non-profit Lutheran ministry and community. Holden Village operates under a Special Use Permit with the Forest Service. Holden Village is home to about 60 year-round residents and hosts approximately 5,000 visitors per year.

The Site, shown on Figure 3, includes the entire area impacted by releases of hazardous substances from past mining activities that cause acidic drainage from the mine (AMD) and the waste rock and tailings piles (ARD). The Site also includes about 10 miles of the Railroad Creek drainage extending downstream from the mine to Lake Chelan, Holden Village, and outlying areas such as Honeymoon Heights (described in more detail in Section 5.2).[3]

The Site is one of the larger cleanup sites in the State of Washington, extending from the former mine operations along an approximately 10-mile reach of the Railroad Creek Watershed to Lake Chelan. Contamination from the mining operation results primarily from metals and depressed pH and, to a lesser extent, petroleum hydrocarbons.

---

[3] Although the mine is a bit less than 9 miles from Lake Chelan, the total length of the watershed impacted by releases from the mine is about 10 miles based on meanders in Railroad Creek.

Major features of the mine area cover about 125 acres and include a former Mill Building, approximately 8.5 million tons of tailings piles, and about 250,000 tons of waste rock piles. The 1500 Level Portal (Main Portal) of the mine and the former Mill Building are located on the south side of the valley, near the base of a relatively steep valley slope. The waste rock piles and tailings piles are located south of and adjacent to Railroad Creek.

AMD from the mine and ARD from the waste rock and tailings piles continue to release substantial quantities of metals from the waste rock and tailings piles into surface water and groundwater at the Site. The Main Portal discharges highly contaminated water at flow rates between 90 gallons per minute (gpm) in the fall and around 1,200 gpm in the spring. These and other sources on the Site contain concentrations of hazardous substances exceeding levels that are protective of human health and the environment. Groundwater discharges into surface water with concentrations of hazardous substances exceeding levels protective of aquatic receptors. Surface water and sediment contain hazardous substances above levels protective of aquatic life.

1.1 Agency Authorities and Roles

The United States Department of Agriculture, Forest Service (Forest Service) is the lead agency for CERCLA site activities. The Forest Service is acting in cooperation with the Washington State Department of Ecology (Ecology) and the United States Environmental Protection Agency (EPA). The Forest Service, Ecology and EPA are collectively referred to as the Agencies.

The Forest Service and EPA are issuing this ROD under the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Section 117(b), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. § 300.430(f)(4).

In addition, independent of the federal application of CERCLA, the State of Washington is concurrently asserting jurisdiction over the Site cleanup. The State of Washington's cleanup authority for this Site is MTCA, which is applicable to the Site under state law [RCW 70.105D]. Ecology is concurrently adopting this ROD as a cleanup action plan under MTCA [see WAC 173-340-380(4)]. While many provisions of MTCA are applicable or relevant and appropriate requirements (ARARs) under CERCLA and are thus germane to the CERCLA decision-making process, this ROD also includes discussion of MTCA provisions to serve Ecology's purposes in making a cleanup action decision

under MTCA. Where such discussion occurs, it is generally identified as "for Ecology's purposes" and is not part of the CERCLA decision-making process.

The majority of the land at the Site is within the Okanogan-Wenatchee National Forest. However, the Mill Building, a portion of the main East and West Waste Rock Piles, and Honeymoon Heights are located on private land owned by Holden Village.

The Agencies anticipate that the cleanup will be funded by the potentially responsible party (PRP), Intalco Aluminum Corporation, in accordance with a Consent Decree to be negotiated with the Agencies, or a Unilateral Administrative Order (UAO).

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Mining History

Mining first started in the late 1800s and early 1900s along Railroad Creek. The underground mine and facilities that later became known as the Holden Mine were initially developed in the area known as Honeymoon Heights (Figure 3). The Honeymoon Heights area consists of six mine adits (mine entrances) and associated piles of waste rock from underground tunnels developed during early mining operations at the Site.

Howe Sound Company took over mining operations in 1938. The mining company acquired permits from the Forest Service and other relevant agencies to further develop the mine and construct the mill and related facilities as well as a mine town site, Holden Village. Mine development included an ore haul-out tunnel (the Main Portal) and a mine ventilation tunnel constructed near the level of the mill facility, noted on mine maps as the 1500 Level. Ore milling began in 1938 and continued until 1957.

In 1960, Howe Sound transferred its patented land and unpatented mining claims and other assets to the Lutheran Bible Institute (LBI). In 1961, LBI transferred the property to Holden Village, a non-profit corporation, to operate a Lutheran ministry and community in the former miners' town site (see Figure 4).

Ore removal resulted in the reported development of about 56 miles of underground mine workings. Old mine maps show that the mine workings included 14 primary mine levels and approximately the same number of secondary mine levels. Horizontal levels were developed for ore removal every

50 to 100 feet from the top to bottom extent of the mine workings. The different levels of the mine were connected by a series of inclines, two shafts, and air passageways. The mine extended to a depth of approximately 800 feet below Railroad Creek.

Economic minerals—primarily copper, zinc, silver, and gold—were removed from the ore by crushing and processing in the mill. The resulting ore concentrate was then transported off site for smelting. On-site ore processing generated approximately 10 million tons of tailings, which are a mixture of silt and fine sand resulting from ore crushing. Approximately 1.5 million tons of tailings were used to backfill part of the mine during operations to increase the stability of the underground openings below the 1500 Level.

The remainder of the tailings were hydraulically placed in three piles covering approximately 75 acres north and east of the Mill Building (Figure 4). The piles range from about 40 to 120 feet high and contain an estimated 8.5 million tons of tailings. Construction of the tailings piles required relocating Railroad Creek north of the existing stream channel; therefore, portions of the tailings piles are over the now-abandoned channel.

Two large waste rock piles were placed on the west and east sides of the Mill Building (Figure 4). The waste rock piles consist of an estimated 250,000 tons of rock removed from the underground mine that did not contain sufficient concentrations of economic minerals to warrant processing in the mill.

After mining operations ceased in 1957, the mine partially filled with groundwater and water began to drain out of the 1500 Level Main Portal. Drainage from the Main Portal varies annually from about 90 gpm in the fall to around 1,200 gpm (and occasionally higher) in the spring, and discharges overland into Railroad Creek. An underground collapse in 1970 temporarily blocked water discharge from the Main Portal until the water pressure was sufficient to breach the collapsed rock and soil overburden. The surge of released water eroded a portion of the West Waste Rock Pile and turbid water entered Railroad Creek. The force of the released water eroded a cut approximately 10 feet deep where it crossed the road by Holden Village's garage (Forest Service 1970).

2.2 Enforcement History

In 1993, the Agencies identified Alumet Corporation (a successor in interest to Howe Sound) as a potentially responsible party (PRP) for the Holden Mine

cleanup action. On April 11, 1998, Alumet and the Agencies entered into an Administrative Order on Consent/Agreed Order (AOC) to conduct a Remedial Investigation/Feasibility Study (RI/FS) for cleanup of the Site. Alumet Corporation subsequently merged into Intalco Aluminum Corporation and is hereafter referred to as Intalco. Intalco and the United States also entered into a Consent Decree on April 5, 2000, for reimbursement of past response costs and other Consent Decree requirements.

2.3 Past Site Response Actions

Between 1989 and 1991, the Forest Service performed the following site response actions:

- Regraded the tailings pile surfaces to increase surface water runoff;
- Constructed diversion ditches to reduce surface water run-on to the tailings piles;
- Constructed channels within the Copper Creek drainage to direct flow between Tailings Piles 1 and 2 through two culverts located at the southern edge of the piles;
- Reduced erosion of the tailings piles along Railroad Creek by placing riprap on the stream banks; and
- Placed about 6 inches of gravel over the surface of the tailings piles to reduce wind-borne transport of tailings.

The Forest Service, with help from Holden Village, revegetated portions of the tailings piles and conducted limited revegetation studies in several test plots on the piles in the 1990s. Reports from the Forest Service indicate that some of these efforts have been relatively successful, especially when biosolids were added as a soil amendment (presentation by George Scherer, Forest Service, at Holden Mine Acid Mine Drainage Workshop, October 1999).

Active treatment of the acid mine drainage (AMD) was not included in the Forest Service actions. However, to add alkalinity and increase the precipitation of metals from the portal drainage before it reaches Railroad Creek, limestone rock fragments were placed on the drainage substrate as a form of passive treatment. This method was not successful, because the limestone surfaces were quickly coated (or blinded) with metal precipitates.

In 2000, Intalco secured the mine entries and fenced off the abandoned Mill Building to prevent trespass. Subsequently in 2003, 2004, and 2006, Intalco completed the following additional time-critical stabilization measures to control erosion and repair flood damage to the tailings piles:

- In October 2003, flooding caused damage at the Site that warranted immediate action to avoid further damage to the environment. Of particular concern was the damage to riprap protection along the toe of the tailings piles, as well as a gully that formed across Tailings Pile 1. The Forest Service approved an Action Memorandum on November 12, 2003, for a time-critical removal action to be conducted under the existing CERCLA AOC between Intalco and the Agencies. The time-critical removal action began on November 14, 2003, and was successfully completed before November 25, 2003.

- In 2004, additional stream bank protection and stabilization of the Railroad Creek channel at and upstream of the vehicle bridge was required to prevent further erosion of stream bank sediment that could potentially release contaminants to the environment. It was important to complete this work without delay because of the potential for high water during winter storms and spring 2005 snowmelt to erode the channel upstream of the bridge. The Forest Service approved an Action Memorandum on August 23, 2004, for a time-critical removal action under the AOC. This time-critical removal action began on October 4, 2004, and was successfully completed before October 25, 2004.

- During the spring of 2006, high water in Railroad Creek and Copper Creek resulting from rapid snowmelt caused additional erosion of Tailings Piles 1 and 2, requiring more repairs. The Forest Service approved an Action Memorandum on August 28, 2006, for a time-critical removal action under the existing AOC. This time-critical removal action began on September 27, 2006, and was successfully completed by October 1, 2006.

2.4 Site Investigation Activities

The 1998 AOC documents an agreement the Agencies reached with Intalco directing Intalco to perform a detailed cleanup study of the Site. The study information, data, and regulatory and technical analyses used for Site characterization, alternatives analysis, and selection of a final remedy are presented in a series of documents and reports in the Administrative Record. The cleanup study documented findings in a Remedial Investigation (RI) that

characterized the conditions, nature and extent of contamination, and site risks. A Feasibility Study (FS) evaluated remediation options. This section summarizes the activities conducted as part of the overall cleanup study of the Site.

2.4.1 Remedial Investigation

Intalco conducted the RI between 1997 and 1999. The RI included the sampling and analysis of soil, surface water, groundwater, and sediment; and documented other site information. Limited ecological and human health risk assessments were conducted as part of the RI. The Draft Final Remedial Investigation (DFRI) was submitted on July 28, 1999.

On February 8, 2002, the DFRI (Dames and Moore 1999) was accepted as final by the Agencies (Forest Service 2002). Acceptance was based on the expectation that the subsequent Feasibility Study would provide additional information missing from the RI to resolve a number of Agency comments on the DFRI report.

Additional site investigations completed before and after submittal of the DFRI report are also relevant to the development and analysis of candidate remedial alternatives. The following transmittals summarize the results of additional site investigations:

- Holden Mine Fall 2000 and Spring 2001 Underground Investigation Data Transmittals (URS 2001a; URS 2001b). These documents present the findings of three investigations into the 300, 1100, and 1500 levels of the underground mine in November 2000, April 2001, and May 2001.

- Fall 2001 and Spring/Summer/Fall 2002 Hydrogeologic Investigation Data Transmittals (URS 2002a; URS 2002e; URS 2002f; URS 2003b). These documents present the results of the installation and sampling of five new downgradient groundwater monitoring wells from November 2001 through October 2002.

- Fall 2001 Geotechnical/Geochemical Investigation Data Transmittal (URS 2002c). This document presents the results of geotechnical and geochemical sampling and analysis of tailings performed in conjunction with the fall 2001 hydrogeologic investigation noted above.

- Fall 2001 and Fall 2002 Additional Lake Chelan Sediment Sampling Data Transmittals (URS 2002d; URS 2003c). These documents present sediment

chemistry, grain size analyses, and toxicity testing data associated with sediment sampling performed at Lucerne bar and Stehekin (the reference site) in Lake Chelan. Sampling was conducted in November 2001 and October 2002.

- Final Monitoring Report – Bat Monitoring and Winter Survey of Underground Mine Workings at the Holden Mine Site (URS 2003a). This document presents the results of site surveys and remote monitoring conducted in 2001 and 2002 within the underground workings of the Holden Mine to establish the presence or absence of bats.

- Spring 2003 Surface Water Monitoring Data Transmittal (URS 2003d). This document presents the results of Railroad Creek and portal drainage water quality sampling conducted from May 20 through May 21, 2003.

- Results of Humidity Cell Testing on Tailings (SRK 2003). This document presents the results of humidity cell testing conducted in 2002 and 2003 on three tailings samples collected from the Holden Mine Site during the fall 2001 geochemical investigation.

2.4.2 Natural Resources Damages Assessment

In addition, as agreed upon in the AOC, a Draft Injury Determination Memo, dated February 15, 2002, was prepared to summarize potential injuries to natural resources at the Site to evaluate the potential for coordinated remedial and natural resource restoration activities.

2.4.3 Feasibility Study

Initial phases of the FS began in 1999. The Draft Feasibility Study (DFS) was delivered to the Agencies for review on June 12, 2002. There were eight alternatives with eight sub-alternatives analyzed in the DFS as well as a "no action" alternative. The Draft Final Feasibility Study (DFFS) was delivered to the Agencies and Trustees for review on February 19, 2004 (URS 2004). Sixteen alternatives and sub-alternatives were analyzed in the DFFS along with the no action alternative.

During the spring and summer of 2005, following Intalco's submittal of the DFFS, the Agencies concluded that none of the 16 alternatives and sub-alternatives presented within Alternatives 1 through 8 would meet the threshold CERCLA remedial action selection criteria, based on information provided by

Intalco. The threshold requirements under CERCLA are protection of human health and the environment, and compliance with applicable or relevant and appropriate requirements (ARARs).[4]

---

[4] Applicable requirements are defined in the NCP(40 C.F.R. § 300.5) as: "Applicable requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."

Relevant and Appropriate requirements are defined in the NCP (40 C.F.R. § 300.5) as: "Relevant and appropriate requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate."

ARARs fall into three broad categories, based on the manner in which they are applied: chemical-, action-, and location-specific.

Chemical-specific ARARs include requirements that regulate the release to, or presence in, the environment of materials with certain chemical or physical characteristics, or containing specified chemical compounds. The requirements are usually either health- or risk-based numerical values or methodologies that establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment.

Action-specific ARARs set performance, design, or similar controls or restrictions on particular kinds of activities related to the management of hazardous substances, pollutants, or contaminants. The need to follow these ARARs depends on the particular remedial action selected for implementation. Action-specific ARARs indicate how, or to what level, the alternative must achieve the requirements. For example, the National Pollutant Discharge Elimination System (NPDES) discharge requirements are an action-specific ARAR when the remedy includes a groundwater treatment facility that

MTCA has similar threshold requirements. A detailed discussion of the threshold requirements is presented in Section 4.1.1.2 of the Supplemental Feasibility Study (SFS) prepared by the Agencies (Forest Service 2007b). The DFFS alternatives that failed to satisfy the threshold requirements under CERCLA and MTCA cannot be considered as a final cleanup action for the Site. Based on this determination, the Agencies proposed consideration of new alternatives.

The Agencies proposed an alternative referred to as the Agencies Proposed Remedy (APR). The APR combined elements of some of the alternatives described in the DFFS and included a partially penetrating barrier to contain groundwater for collection and treatment. On September 1, 2005, the Agencies transmitted the APR to EPA's National Remedy Review Board (NRRB) for evaluation (Hart Crowser 2005a).

On November 18, 2005, Intalco proposed consideration of a new remedial alternative, identified as Alternative 9 (URS 2005). Alternative 9 consisted of DFFS Alternative 3b, combined with pumping from wells and seeps to clean up

---

discharges treated effluent to surface water. In general, only the substantive requirements of an ARAR need to be implemented at a site.

Location-specific ARARs are restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. They relate to the geographic or physical position of a site. Remedial actions may be restricted or precluded depending on the location or characteristics of a site and the requirements that apply to it. Location-specific ARARs may apply to actions in natural or manmade features. Examples of natural site features include wetlands and floodplains. An example of a manmade feature is an archaeological site. Also, since the Site is located within the Glacier Peak Wilderness Area Class 1 Airshed, specific air quality ARARS need to be addressed under the Clean Air Act (42 U.S.C. § 7401 et Seq.; 40 C.F.R. Part 50) and related regulations.

"To be considered" materials (TBCs) are non-promulgated criteria, advisories, guidance, and proposed standards issued by federal, state, or tribal governments that, although not legally enforceable, may be helpful in establishing protective cleanup levels and developing, evaluating, or implementing remedy alternatives. TBCs are not ARARs but are meant to complement the use of ARARs. If no ARARs address a particular chemical or situation, or if existing ARARs do not provide adequate information, TBCs may be available for use in developing remedial alternatives.

groundwater from below a limited area of Tailings Pile 1. For consistency in alternative numbering, the APR was established as Alternative 10.

After meeting with the NRRB and reviewing the NRRB's comments, and after meeting with Intalco and Holden Village, the Agencies concluded that Alternatives 1 through 9 would not meet the threshold criteria for selection of a cleanup action [40 C.F.R. § 300.430(f)(1)(i)(A) and WAC 173-340-360(2)], and that available information was not sufficient to demonstrate that Alternative 10 satisfied the threshold requirements. Therefore, none of these potential remedies qualified as a final remedy. Accordingly, the Agencies developed Alternative 11 by combining elements of the earlier alternatives to create a proposed remedy that they believed satisfied the CERCLA and MTCA threshold criteria, and Alternative 12, a true "no-action" alternative as required under CERCLA. Alternatives 9, 10, 11 and 12 were further evaluated in the Supplemental Feasibility Study (SFS, Forest Service 2007b).

On September 13, 2007, the Agencies initially accepted a final Feasibility Study (Forest Service 2007d) consisting of:

- The Draft Final Feasibility Study and Intalco's Alternative 9 Description as modified and supplemented by the Agencies' Comments on the Draft Final Feasibility Study (Forest Service 2007a),

- The Agencies' comments on Intalco's Alternative 9 Description (Forest Service 2007c), and

- The Supplemental Feasibility Study (Forest Service 2007b).

On October 15, 2007, Intalco proposed another new remedial approach that it referred to as Alternative 13 (Intalco 2007). Alternative 13 featured the relocation of Railroad Creek and used the existing creek bed to collect contaminated groundwater from the tailings piles rather than using a barrier wall and collection trench, as proposed in Alternative 11. The Agencies concluded there was not sufficient information in the Administrative Record file at that time to assess whether Alternative 13 would satisfy the CERCLA and MTCA requirements.

In 2008 and 2009, Intalco performed additional field investigations to address data gaps that the Agencies had identified. Based on the initial results of these investigations, Intalco revised Alternative 13, designating the new alternative as Alternative 13M. Intalco presented the results of the additional investigations,

including an evaluation of Alternative 13M and Alternative 11, in the Draft Alternative 13M Evaluation Report (ERM and URS 2009).

In June 2010, the Agencies completed the Addendum to the 2007 Supplemental Feasibility Study (ASFS) (Forest Service 2010a) to present relevant information not included in the Draft Alternative 13M Evaluation Report, update the remedial action objectives (RAOs), and to describe and evaluate three remedial alternatives that were developed after the 2007 Supplemental Feasibility Study (Alternatives 11M, 13M, and 14). As part of preparing the ASFS, the Agencies developed a new alternative (Alternative 14) to address certain Alternative 13M deficiencies related to protection of surface water and remediating soil to achieve soil cleanup standards, and also refined Alternative 11 (now referred to as Alternative 11M) to reflect the additional data Intalco collected in 2008 and 2009.

The Agencies did not require Intalco to resubmit the Feasibility Study. Rather, the Agencies accepted a final Feasibility Study (Forest Service, March 30, 2010) that consists of:

- The Draft Final Feasibility Study (URS 2004) and Intalco's Alternative 9 Description (URS 2005), as modified and supplemented by the Agencies' Comments on the Draft Final Feasibility Study (Forest Service 2007a) and the Agencies' comments on Intalco's Alternative 9 Description (Forest Service 2007c);

- The SFS (Forest Service 2007);

- Intalco's Draft Alternative 13M Evaluation Report (August 14, 2009) as modified and supplemented by the Agencies' comments (Forest Service 2010b); and

- The ASFS (Forest Service 2010).

These documents are included in the Administrative Record for the Site.

3.0 COMMUNITY PARTICIPATION

The Agencies developed a community relations plan (CRP) for the Site in April 1998. The CRP was designed to promote public awareness of cleanup activities and investigations, and to promote public involvement in the decision-making

process. This section summarizes the community relations activities performed by the Agencies during the remedy selection process.

Interviews were held in 1998 in communities near the Site: Holden Village, Chelan, and Wenatchee. These interviews provided the Agencies with background on local awareness of, and interest in the Site. Holden Village is well known in the area. The CRP summarized the concerns of local citizens, interest groups, industries, and local government representatives. Community participation activities included personal interviews, distribution of fact sheets, newspaper notices, and public notices. During the RI/FS, the Agencies consulted with Holden Village about anticipated future land, groundwater, and surface water uses at the Site.

The April 1998 Community Relations Plan was revised in December 2007 and again in March 2010 to provide a framework for informing the public about the draft Proposed Plan and other site activities. Before release of the Proposed Plan, the Agencies participated in a series of meetings (from the fall of 2007 through early summer 2010) in which remedial alternatives were discussed with Intalco and representatives of Holden Village.

The Proposed Plan was released for public comment on June 23, 2010. The initial 45-day comment period was extended for an additional 45 days at Intalco's request. Public comments were received over a 90-day period, ending September 22, 2010. This included four public meetings that the Agencies arranged in Chelan, Wenatchee, Holden, and Seattle. A court reporter prepared a transcript of oral comments from these meetings. Comments were also received by US Postal Service and e-mail. The Agencies received comments from more than 100 individuals and organizations. These comments are addressed in the Responsiveness Summary, included as Part 3 of this ROD.

Documents considered or relied on in selecting the final remedy, including public comments on the Proposed Plan, are available to the public in the Administrative Record. The Administrative Record is available at the Okanogan-Wenatchee National Forest Headquarters in Wenatchee, at Ecology's Central Regional Office in Yakima, and at EPA's Region 10 office in Seattle.

4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

This ROD presents the final cleanup of impacts from past and ongoing soil, sediment, surface water, and groundwater contamination at the Site. The remedy selected by the Agencies and documented in this ROD includes

remedial actions necessary to protect human health and the environment. While contamination will remain at the Site, the Selected Remedy will protect human health and the environment.

The selected remedy will be implemented in phases, including an early works phase (in part, conducted under a Removal Action) to prepare for two phases of major construction. The phases are described in the following sections.

4.1 Early Works

The early works phase consists of Site access improvements that are necessary before major construction starts. The early works include dock and barge unloading facility improvements, and improvements to the Lucerne-Holden Road that will be used for site access. The access road improvements will include widening some areas of the road, construction of turnouts, temporary and permanent bridge improvements, and a new road segment so that construction traffic can bypass Holden Village. Other early works activities include construction staging areas; relocation or protection of Holden Village infrastructure (e.g., water supply and vehicle maintenance facilities); construction of hydraulic bulkheads to contain groundwater in the underground mine; and limited removal or capping of impacted soil in specific areas (e.g., staging areas).

4.2 Phase 1

The first major construction phase of the remedy will include construction of a groundwater treatment facility, construction of a groundwater barrier around Tailings Pile 1 and the Lower West Area, beginning *in situ* soil treatment in some areas of interest (AOIs), and regrading and capping the main waste rock piles and the tailings piles. The cap will be designed to eliminate the risk of dispersion from wind and water erosion, prevent human contact with the wastes, and eliminate unacceptable risk to terrestrial plants and animals. Groundwater from the Lower West Area and Tailings Pile 1 area, seeps, and flow from the mine will be conveyed to the new groundwater treatment facility.[5] *In situ* treatment of

[5] At various times, both Intalco and the Agencies have proposed use of one or two facilities for treatment of groundwater, to address differences in water quality and hydraulic gradient in different areas of the Site. For convenience, this ROD refers to a single water treatment facility that will likely be located north of Railroad Creek, but recognizes that final location, number of treatment facilities and treatment technology will be based on design studies and approved by the Agencies. Also, since the Selected

impacted soil that is not amenable to consolidation and capping is anticipated to continue periodically over time, depending on results of treatability studies and monitoring.

4.3 Phase 2

A second phase of major construction will follow completion of the first phase. The Agencies determined it is appropriate to begin the second phase of heavy construction 5 years after completion of the first phase to reduce the adverse effects of construction on the residents of Holden Village. While this approach will extend the period during which groundwater that exceeds cleanup levels is only partially contained and treated, the first phase of remedy construction will prevent risks to human health and most terrestrial receptors, except in the wetland downgradient of Tailings Pile 3. The first phase of heavy construction will also significantly reduce the release of groundwater containing hazardous substances into Railroad Creek. The remaining release of contaminated groundwater, ARD, will be addressed by the second phase of heavy construction.

During the interim between the first and second phases, the groundwater treatment plant will be fully operational and its design and operation can be modified as needed to improve treatment effectiveness. This is an important aspect of the remedy, since completion of the second phase will roughly double the flow of groundwater that must be treated to a total of about 600 million gallons per year.

The second phase of major construction includes installation of a second groundwater barrier and collection system downgradient of Tailings Piles 2 and 3, and possibly expansion of the groundwater treatment facility. This second and final phase is planned to occur 5 years after the first phase of major construction is complete. The delay between phases will allow Holden Village to reestablish operations that will be interrupted during the first phase.

Before completion of the Proposed Plan and during public comments, Holden Village managers and residents expressed concerns that construction will have such a major impact on life in the Village that its continued viability will be at

---

Remedy will be implemented in phases, the timing for expansion of the groundwater treatment facility will be determined during remedial design.

risk. The Agencies will allow a 5-year hiatus between major stages of construction to reduce the effects of construction on Holden Village residents and operations.

Intalco has stated, but has not demonstrated, that construction of the second groundwater barrier wall and collection system will be unnecessary once the first phase of the remedy is completed. Currently, there is no showing that without the second phase of remedy construction, groundwater cleanup levels would be met in groundwater under and downgradient of Tailings Piles 2 and 3.

The period between the first and second phase presents an opportunity for Intalco to collect data in an effort to support a proposal to modify the second phase. The ROD allows for the collection of additional data following implementation of the first phase cleanup components, and includes the provision that the barrier wall design could be modified or would not need to be installed, if demonstrated to satisfy ARARs and be protective within a timeframe comparable to the Selected Remedy. The second phase of the remedy would not need to be installed only if it can be demonstrated to the Agencies' satisfaction that:

1. Groundwater concentrations are reduced to achieve surface water cleanup levels before that portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates; and

2. One of the following: a) groundwater meets MCLs below Tailings Piles 2 and 3, as well as throughout the plume; or b) groundwater that exceeds drinking water standards will be contained within a WMA; or c) an ARAR waiver for MCLs beneath Tailings Piles 2 and 3 based on technical impracticability from an engineering perspective is justified.

Such a change would require a ROD Amendment. The basis for the change must be demonstrated within three years of substantial completion of the first phase of remedial construction, so that a decision can be made in the fourth year. Unless the second phase groundwater barrier and collection system is eliminated, the second phase of remedial action is expected to be designed in the fifth year and constructed immediately thereafter.

5.0 SITE CHARACTERISTICS

This section summarizes information obtained through the RI/FS process. It includes a description of the conceptual site model upon which investigations,

the assessment of risks, and response actions are based. The major characteristics of the Site and the nature and extent of contaminant releases are summarized below. More detailed information is contained in the RI/FS and supporting documents, which are included in the Administrative Record.

5.1 Conceptual Site Model

The conceptual site model depicted on Figure 5 shows the relationships between the sources of hazardous substances and exposure pathways for human and ecological receptors at the Site. The primary sources of contamination are the tailings piles, waste rock piles, and drainage from the mine, which all release hazardous substances into the groundwater and surface water. The tailings and waste rock piles are the source of ARD that seeps into the groundwater and later enters Railroad Creek (and in the case of the tailings piles, some seeps directly enter the creek, e.g., SP-2). The mine is a source of AMD that currently flows from the 1500 Level Portal through an open channel to enter Railroad Creek at the sampling point designated P-5. Additional sources of hazardous substances include soil that is impacted by dispersion of the tailings, as well as mine operations such as equipment maintenance. Potential human receptors include Holden Village residents, recreational users of the Site, and workers. Ecological receptors include fish, benthic macroinvertebrates, and other organisms in Railroad Creek, as well as a variety of plants and wildlife.

5.2 Physical Characteristics of the Site

The Site is located in the Railroad Creek Watershed, which is situated approximately two-thirds of the way up the west side of Lake Chelan. The Site is within the Okanogan-Wenatchee National Forest except for some patented mining claims owned by Holden Village (see Figure 4) and some private residences near the mouth of Railroad Creek at Lucerne. The watershed is generally oriented in an east-west direction and is approximately 20 miles long. The Railroad Creek drainage is generally a glacially carved u-shape, with steep side slopes. The portion of the drainage near Lake Chelan slopes gently at the mouth of the creek for approximately one-half mile. It then becomes very steep, with several waterfalls. The drainage then transitions to a more moderate gradient that extends westward past the mine to the western end of the drainage, where the drainage again steepens before reaching its headwaters at Cloudy Pass. Elevations of Railroad Creek range from about 1,100 feet above sea level (asl) at Lucerne, which is located on Lake Chelan, to about 6,500 feet asl at the headwaters in the Glacier Peak Wilderness. The Holden Mine

workings are approximately 10 miles up the Railroad Creek drainage from Lake Chelan.

Railroad Creek is the second largest hydrologic source to Lake Chelan and contributes approximately 10 percent of the annual basin input. The area where the mine operated is the largest of only a few floodplain valley reaches in the Railroad Creek drainage and one of the few floodplain valleys in the entire Lake Chelan drainage. Therefore, this floodplain valley is important to the overall ecology of the Lake Chelan Basin. The forest surrounding the Site provides key habitat for riparian-dependent species and important resources for both riparian and upland species.

The Main Portal of the mine and the former Mill Building are located on the south side of the watershed, near the base of the relatively steep valley slope (Figure 4). Most of the abandoned mine facilities and tailings are between 3,200 and 3,450 feet asl; for comparison, the elevation of Railroad Creek is about 3200 feet asl adjacent to Holden Village . The surface expression of the Honeymoon Heights mine workings range in elevation up to approximately 4,600 feet asl.

5.2.1 Surface Features

The Site includes a number of informal AOIs that were defined for the purposes of the terrestrial ecological evaluation (TEE), as well as other site features. These features are shown on Figure 4 and are described in the following subsections.

Tailings Piles 1, 2, and 3

Tailings at the Site occur in three main piles identified as Tailings Piles 1, 2, and 3, located along the south side of Railroad Creek. Tailings are also dispersed in other areas, such as the east portion of the Lower West Area and an extensive area impacted by wind-blown tailings north and east of the main tailings piles, as described below. The three main piles, which range in height up to about 120 feet above Railroad Creek, are estimated to contain approximately 8.5 million tons of tailings covering an area of roughly 75 acres.

East and West Waste Rock Piles

The East and West Waste Rock Piles consist of an estimated 250,000 tons of waste rock that cover about 8 acres, and range in height up to about 165 feet.

Honeymoon Heights Waste Rock Piles

The Honeymoon Heights Waste Rock Piles consist of five discrete waste rock piles associated with the 300, 550, 700, 800, and 1,100 Level mine portals. These waste rock piles are estimated to have a combined volume of about 49,000 cy, covering an area of about 5 acres. The Honeymoon Heights Waste Rock Piles are located between about elevation 3,800 to 4,600 feet across a relatively steep north-facing slope that varies from about 50 percent (2H:1V) to 200 percent (1H:2V).

The Honeymoon Heights Waste Rock Piles are located on private land, except for possibly a small portion that may be located on National Forest System land. The piles are located in an area that is biologically important as functional riparian habitat as described in the Draft Terrestrial Ecological Evaluation (TEE) completed in March 2009 (ERM 2009).

TEE Areas Downslope from the Honeymoon Heights Waste Rock Piles

The TEE described an AOI consisting of about 3 acres of riparian forest habitat directly downslope from the Honeymoon Heights Waste Rock Piles (DSHH) associated with the 300, 550, 700, 800, and 1100 Level portals, as shown on Figure 4. Similar to the Honeymoon Heights Waste Rock Piles, the DSHH areas are located on a relatively steep north-facing slope.

The DSHH areas are on private land in an area that is biologically important as functional riparian habitat.

Ballfield Area

The Ballfield Area covers an area of about 8 acres, including the former miners' village baseball field, a campground, a portion of a hiking trail (formerly the Mary Green Mine haul road), and the adjacent area. The Ballfield Area is primarily on National Forest System land, although a small portion is on patented land owned by Holden Village.

Holden Village

The former miners' town site covers about 11 acres and includes about 25 buildings, as well as roads and landscaped areas. Holden Village continues to occupy the former company town under a Special Use Permit from the Forest Service. The residential buildings in the village are located on National Forest

System land. Approximately 60 adults and children live at Holden Village year-round. In addition, approximately 5,000 to 6,000 people visit the facility each year, with each person generally staying 2 to 7 days. Holden Village uses part of the private property (patented mining claims) it owns for infrastructure support—hydroelectric power generation, recycling, and woodcutting—and vehicle maintenance and parking.

Lower West Area

The Lower West Area covers an area of about 15 acres located south of Railroad Creek and west of Tailings Pile 1. The Lower West Area is roughly bisected by a road running south from the bridge over Railroad Creek to the Holden Village Maintenance Yard. The eastern portion of the Lower West Area is referred to as Lower West Area-East and the western portion is called Lower West Area-West, excluding the Lagoon Area. An ephemeral pond, referred to as the Lagoon, is located along this road and is considered as a separate AOI, as discussed below.

Lagoon Area

The Lagoon Area was reportedly excavated as a surface water management facility during mine operations, and may also have been used for temporary storage of tailings slurry that was pumped to the tailings piles, or perhaps for backfilling portions of the underground mine. The Lagoon Area covers an area of about 1 acre and contains visible tailings accumulations. There are also tailings in the soil within the former Lagoon footprint.

Wind-Blown Tailings Area

The Wind-Blown Tailings Area extends over an area of about 77 acres located north and east of Tailings Pile 2 and Tailings Pile 3. This area is mostly coniferous forest, with a strip of riparian wetland habitat along Railroad Creek. The Wind-Blown Tailings Area has intermittent visible accumulations of tailings. A portion of this area nearest to the creek was clear-cut and became reforested in the early 1960s; other areas were selectively harvested and have residual old growth structure. The remainder has not been logged and has well-established native vegetation.

Maintenance Yard

The Maintenance Yard is an area of about 1 acre where Howe Sound and, subsequently, Holden Village performed equipment maintenance. The surface

of the Maintenance Yard is densely compacted gravelly soil with little or no existing vegetation.

Former Mill Building

The former Mill Building is located between the East and West Waste Rock Piles, and extends over an area of about 2 acres. The ground surface is largely covered by concrete slabs and walls, along with debris and remnants of the steel superstructure. The dilapidated condition of the former Mill Building did not allow safe access during the RI to fully characterize potential hazardous substances.

Ventilator Portal Surface Water Retention Area

The Ventilator Portal Surface Water Retention Area is apparently a former water detention pond that is located downslope of the 1500 Level Ventilator Portal. The former pond in the Surface Water Retention Area is an excavation with a perimeter berm covering less than about a half acre. There are tailings in the soil within the former pond footprint.

Lucerne-Holden Road

In September 2009, the Forest Service identified an April 24, 1940, memorandum from the District Ranger, W. O. Shambaugh (Forest Service 1940), indicating that the Howe Sound Company was proceeding with plans to resurface the road between Lucerne and Holden (Figure 3). The memorandum stated that the contractor for the job would install a rock crusher on the "waste dump at the mine" to obtain material for the resurfacing. Subsequent file searches by the Forest Service have not confirmed that this resurfacing plan was actually implemented. Pending further investigation, the Agencies assume that waste rock may have been used for resurfacing the Lucerne-Holden Road and that those portions of the road may be a source of hazardous substances within the Site.

Other Areas of the Site

There are several other areas of the Site where former mine activities are associated with the release of hazardous substances to the environment. These areas include:

Underground Mine Workings. Approximately 10 million tons of ore were excavated from the Holden Mine during its operation. The tunnels excavated to develop the mine reportedly total 56 miles in length. Within these mine workings, dissolved metals and sulfates from the walls of the openings (and from tailings that were backfilled into the mine) add to the contaminant load carried by the portal drainage to Railroad Creek. In addition, air flow through the workings increases oxidation of sulfide minerals which, in turn, increases solubility of metals, further increasing the contaminant load.

Both Intalco and the Agencies assessed the potential for mine subsidence. Intalco reported that the rock spanning the uppermost stopes (large open underground rooms where the ore was excavated) within the mine is "marginally stable." Analysis by the Agencies indicated that there is about a 75 percent probability that these rock spans (referred to as crown pillars) will someday collapse, and that the resulting ground surface subsidence would likely increase air and water movement through the abandoned workings. An increase in air or water flow through the workings could increase the rate of hazardous substances released from the Main Portal drainage.

Railroad Creek. Railroad Creek, from the Surface Water Retention Area downstream to Lake Chelan, is part of the Site, see Figure 4.

Copper Creek. Copper Creek flows into Railroad Creek from the south, passing between Tailings Piles 1 and 2. Copper Creek has actively eroded portions of both Tailings Piles 1 and 2 (in 2003 and 2006) causing a release of tailings into Railroad Creek. South (upslope) of the mine, a portion of Copper Creek is diverted into a penstock that supplies drinking water and hydroelectric power to Holden Village. Discharge from the generator station north (downslope) of the Maintenance Yard flows overland and into Railroad Creek. This overland flow, referred to as the Copper Creek Diversion, has eroded a portion of Tailings Pile 1 into Railroad Creek.

Riparian Wetland East of Tailings Pile 3. Riparian wetlands covering a total area of approximately 5 acres are located immediately east of Tailings Pile 3 along Railroad Creek. These riparian wetlands are adversely impacted by erosional deposition of tailings, runoff, and shallow groundwater contaminated by seepage from Tailings Pile 3, based on field observations of distressed vegetation and soil staining.

Lucerne Bar. The Lucerne Bar is the area where sediment in Railroad Creek is deposited as the creek discharges into Lake Chelan.

5.2.2 Surface Water Hydrology and Groundwater

Surface water and groundwater are primary pathways for the transport and release of contaminants of concern (COCs) at the Site. Surface water and groundwater on the Site are generally controlled by the physical conditions of the watershed, including the natural topography, geology, and climate as well as mine-related alterations to the topography and geology.

Flow in Railroad Creek is generally low from late summer through winter and highest during the months of May and June, coinciding with snowmelt in the basin. Monthly average stream flow at Lucerne varies from a low of about 21,000 gpm to peak flows averaging 280,000 gpm (USGS 2011).

During spring snowmelt (generally April through July), the primary surface water and groundwater discharges to Railroad Creek occur upstream of the Site and originate as glacial water and snowmelt. For the remainder of the year, storage within the weathered bedrock soil and glacial sand and gravel, as well as storm event precipitation, provide the base flow (groundwater discharging to the creek) for Railroad Creek.[6] On the Site, Railroad Creek is the primary receptor of surface water and groundwater discharging to surface water.

Groundwater is present at the Site in a shallow unconfined alluvial aquifer that is hydraulically connected to Railroad Creek. Figure 6 shows generalized groundwater elevation contours and groundwater flow directions. The DRI, as well as recent investigations, (URS 2008 and URS 2009b) have shown that Railroad Creek consists of alternating segments where groundwater flows upward into the creek (gaining reaches) and where water from the creek flows downward into the alluvial aquifer (losing reaches). Conceptual groundwater flow paths under spring and fall conditions are illustrated on Figure 6 and show a relatively complex relationship between the surface water and groundwater, which affects the transport of contaminants.

---

[6] Flow in Railroad Creek is generally low from late summer through winter. As described in the RI/FS, spring conditions generally refer to the 90-day May to July period when snowmelt causes relatively high groundwater levels and relatively high flow conditions in Railroad Creek. In contrast, fall conditions represent the other 275 days per year (August to April) typified by lower groundwater levels and relatively low flows in Railroad Creek.

5.2.3 Geology

Site geology generally consists of stream alluvium and glacial deposits overlying bedrock. Alluvium on the Site ranges from silty, sandy gravel to coarse gravel that is transported and deposited by surface water. Glacial deposits on the Site consist of a combination of glacial drift and basal till. Glacial drift is silt- to boulder-sized material deposited either by retreating glaciers or from rivers draining glaciers. Basal till is silt- to boulder-sized material deposited beneath or ahead of the glacier. In some locations on the Site, glacial drift has been further reworked by subsequent stream action.

Alluvial soils and glacial outwash deposits are the primary media for groundwater flow that transports contaminants at the Site. The alluvium and glacial materials are underlain at variable depths by bedrock that has been carved by the glaciation process, and includes sedimentary, metamorphic and igneous rock types. Dense basal till has been observed to blanket the bedrock in some of the geologic borings completed in the vicinity of Railroad Creek at the Site.

The permeability of the basal till is expected to be low, based on the higher proportion of fines and increased density of the material. The permeability of the bedrock is also anticipated to be relatively low. The potential exists for preferential groundwater pathways along fractures, joints, and faults within the bedrock. However, even within the preferential pathways, the movement of groundwater within bedrock is anticipated to be relatively low based on observations made during the underground mine investigations.

5.3 Summary of the Nature and Extent of Contamination

This section summarizes the nature and extent of contamination at the Site. Table 1 provides summary statistics for groundwater, surface water, and soil. Sections 7.1 through 7.3 provide additional detail about risks to humans, plants, and animals associated with the contamination.

Sections 5.3.1 through 5.3.5 describe the nature and extent of contamination for each media (groundwater, surface water, sediment, soil, and air, respectively). Key findings from the RI and subsequent investigations include:

- Tailings and waste rock (ARD) and the mine (AMD) contribute to low pH and high metals content in groundwater and surface water that causes significant contamination within the Site.

- Concentrations of hazardous substances in groundwater exceed human health criteria for drinking water in some portions of the Site.

- Groundwater containing concentrations of hazardous substances above levels protective of fish and benthic macroinvertebrates discharges into surface water.

- Where groundwater discharges to surface water, concentrations of hazardous substances in seeps and pore water discharging to Railroad Creek are above levels protective of fish and benthic macroinvertebrates in seeps discharging to Railroad Creek and in pore water.

- Concentrations of hazardous substances in surface water (Railroad Creek and the Copper Creek Diversion) are consistently above levels protective of aquatic health for fish and benthic macroinvertebrates.

- High concentrations of hazardous substances present in pore water, surface water, and sediment have reduced the populations of fish and benthic macroinvertebrates in Railroad Creek adjacent to and downstream of the mine, and have also impacted sediments at the Lucerne Bar.

- Concentrations of hazardous substances in mine tailings, waste rock, and soil at the Site exceed criteria for protection of human health, including direct contact and ingestion, and criteria for protection of the environment.

- Tailings pile slope instability from an earthquake or erosion presents a risk of additional hazardous substance releases into Railroad and Copper Creeks.

5.3.1 Groundwater

Groundwater exceeds regulatory levels for drinking water or levels that are protective of aquatic organisms in Railroad Creek (into which groundwater eventually discharges) for aluminum, cadmium, copper, iron, lead, and/or zinc at a number of locations at the Site, most notably from the Main Portal, seeps, Tailings Piles 1, 2, and 3, the East and West Waste Rock Piles, the Honeymoon Heights Waste Rock Piles, and the Lower West Area. Tables 2 and 3 show screening levels (chemical-specific ARARs) and Table 4 shows the concentrations of contaminants of concern in groundwater at various areas of the Site.

In general, groundwater concentrations vary seasonally and are lower in the fall and higher in the spring. Seasonally the concentrations of several contaminants

in groundwater that discharge to surface water exceed water quality criteria for protection of aquatic life by factors of 100 to over 10,000 in several areas.

Varying groundwater flow conditions affect the quality of water that discharges into Railroad Creek, as indicated by Intalco's flow tube analysis for data collected during the RI. Figures 7 and 8 show the location of seeps and groundwater discharge zones (referred to as flow tubes) and Figures 9, 10, and 11 indicate the associated exceedances of screening levels. For some constituents, surface water background concentrations exceed the screening levels and, therefore, are appropriate to consider for protection of aquatic life where hazardous substances are released into Railroad Creek. Groundwater with concentrations of hazardous substances above protective levels continues to discharge into Railroad Creek downgradient of the tailings piles, as shown on Figure 12. Surface water protection levels (based on the protection of aquatic life) are significantly lower (i.e., lower by orders of magnitude) than groundwater standards for protection of human health (e.g., compare Tables 2 and 3).

5.3.2 Surface Water

Surface water in Railroad Creek is impacted by groundwater discharge, including groundwater from the Main Portal (AMD), and contact with tailings and discrete seeps (ARD) (see Figure 13). Groundwater draining from the Main Portal discharges into Railroad Creek and contains concentrations of hazardous substances that exceed state and federal chronic toxicity water quality criteria for the protection of aquatic life. Table 5 presents spring and fall surface water contaminants of concern at several locations along Railroad Creek. Water quality at sampling locations beginning in the reach adjacent to the Lower West Area and extending downstream to the mouth of the creek at Lake Chelan has exceeded screening levels for protection of aquatic life for aluminum, cadmium, copper, iron, lead, and/or zinc.

In general, concentrations are lower in the fall and higher in the spring when concentrations of copper exceed chronic screening levels (i.e., the NWQC) by factors of 8 to 30, cadmium by factors of 5 to 15, and zinc concentrations exceed the NWQC by factors of 3 to 8 at various Railroad Creek sampling locations. Details are shown by comparison of Tables 3 and 5. Elevated hazardous substance concentrations and exceedances of screening criteria for protection of aquatic life were observed at all monitoring locations along an approximately 10-mile stretch of Railroad Creek downgradient of the tailings piles to Lake Chelan. Aquatic life, including both fish and benthic macroinvertebrates, have been heavily impacted for several miles downgradient

of the tailings piles, and the population of the benthic macroinvertebrates do not fully recover to the same population abundance and diversity as upgradient of the Site before entering Lake Chelan (URS 2004).

Surface water in the Copper Creek Diversion (the tailrace channel from the Holden Village hydroelectric plant that discharges to Railroad Creek) has seasonal exceedances of the NWQC (both chronic and acute) for cadmium and the Washington surface water quality standards (WAC 173-201A) for copper, and zinc (Table 5). Concentrations of hazardous substances in the main stem of Copper Creek are at or below state and federal water quality criteria for the protection of aquatic life.

Surface water quality at the Site does not exceed state and federal drinking water criteria.

5.3.3 Sediment

Iron precipitates have formed in Railroad Creek from the release of ferric sulfate and other hazardous substances from the tailings piles. Observed effects include ferricrete and iron and aluminum flocculent, which fills interstitial pore space in the sediment and coats gravel, cobbles, and boulders in the stream channel. The ferricrete and flocculent have caused damage to the aquatic habitat.

Releases from the Site have resulted in concentrations of hazardous substances in sediment in Railroad Creek and the Lucerne Bar that exceed values considered by the state to be protective for freshwater sediment for a number of hazardous substances (Table 6). COCs for sediment include aluminum, cadmium, chromium, copper, iron, silver, and zinc. COCs listed in Table 6 are based on comparison to risk-based criteria that were identified in Table 11 of the Proposed Plan. Ecology is currently developing new freshwater sediment guidance and will in the future rely on freshwater bioassays to assess toxicity for mine sites and other sites with particular geochemical characteristics (Ecology 2011). Criteria for bioassays that will be used for monitoring at Holden are presented in Table 7.

5.3.4 Soil

Soil at the Site is impacted by releases from past mining activities and contains concentrations of hazardous substances that exceed regulatory levels for the protection of human health or the environment (via ingestion, dermal absorption, and inhalation). In addition, leachate from tailings piles has resulted

in high concentrations of hazardous substances impacting pore water in shallow soil (see Figure 12) that drains to surface water. Concentrations of these contaminants of concern are summarized for each AOI in Table 8. The primary contaminants of concern include aluminum, arsenic, cadmium, copper, and lead. Soil in the Lagoon Area and Maintenance Yard is also impacted by petroleum hydrocarbons such as gasoline, diesel fuel, or heavy oils. Terrestrial hazard quotients range up to 300 times the screening level.

5.3.5 Air

Historically, wind-blown tailings expanded the Site footprint, were a nuisance, and posed possible health risks at the Site, but this pathway was largely addressed by actions taken by the Forest Service in 1989–1991. The Forest Service conducted an air quality study in 1994 and identified concentrations of airborne CPOCs were well below EPA risk-based concentrations. The human health risk assessment (HHRA) performed as part of the DRI concluded the inhalation pathway is incomplete and, therefore, there are no significant human health risks related to the soil to air pathway (provided a cap is maintained on the tailings to prevent generation of wind-blown tailings).

6.0 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

6.1 Current Land Use

The Site is situated on National Forest System land administered by the Okanogan-Wenatchee National Forest, with the exception of the patented mining and mill site claims (private land) owned by Holden Village, as shown on Figure 4. At Lucerne there are also residences located on privately owned land.

The current land uses at site AOIs include the following:

- **Holden Village.** Approximately 60 people reside at Holden Village year-round and approximately 5,000 people reportedly visit the facility each year. Holden Village is a Lutheran ministry and community that provides visitors with spiritual and educational programs. Facilities at the Holden Village include buildings, access roads and paths, and maintained landscaping.

- **Tailings Piles 1, 2, and 3.** The emergency evacuation area for the Holden Village is located on Tailings Pile 1. The tailings piles are also visited occasionally for access to hiking trails, and other light recreational use such as frisbee golf.

- **East and West Waste Rock Piles.** The top surface of the West Waste Rock Pile is currently used by the Holden Village to store miscellaneous recyclable materials and is infrequently visited by hikers. The East Waste Rock Pile is used to a lesser extent than the West Waste Rock Pile.

- **Honeymoon Heights Waste Rock Piles.** The Honeymoon Heights Waste Rock Piles are not routinely used; however, hikers may occasionally visit these waste rock piles on hiking trails.

- **Areas downslope of Honeymoon Heights Waste Rock Piles.** The areas downslope of Honeymoon Heights Waste Rock Piles are not currently used with the exception of a hiking trail that passes beneath the 1100 Level and 800 Level waste rock piles.

- **Former Ventilator Portal Surface Water Retention Area.** The former Ventilator Portal Surface Water Retention Area is not currently used.

- **Lower West Area.** The Lower West Area is bisected by a road providing the primary access to the maintenance yard, composting area, and site features associated with mine operations (waste rock piles, former Mill Building, 1500 Level Main Portal, and tailings piles). Large vehicle traffic regularly occurs through the Lower West Area. Holden Village operates a firewood cutting/storage yard and hydroelectric power plant in the eastern portion of the Lower West Area.

- **Lagoon Area.** The Lagoon Area is not currently used, other than for occasional vehicle storage in the flat area immediately north of the Lagoon.

- **Maintenance Yard.** The Maintenance Yard is currently used by the Holden Village for equipment maintenance and storage and includes two maintenance buildings.

- **Wind-Blown Tailings Area.** The Lucerne-Holden Road crosses the Wind-Blown Tailings Area and sustains limited daily vehicle traffic. The Holden Village operates a septic system in the Wind-Blown Tailings Area. Hikers and other recreational users also use or cross the Wind-Blown Tailings Area to access Railroad Creek and a footbridge crossing Railroad Creek east of Tailings Pile 3.

- **Ballfield Area/Wilderness Boundary.** The Ballfield Area is occasionally used by the Holden Village for community activities. The wilderness boundary

area near the Ballfield Area is used by hikers and campers, and a campground is maintained in this area by the Forest Service. A hiking trail passes along the south edge of the ballfield.

6.2 Anticipated Future Land Use

Anticipated future land use at the Site is expected to be generally consistent with current land use (recreational) for the majority of the Site (and residential within Holden Village). Following remedy implementation, some site features may no longer exist (e.g., features that are removed or covered) and some areas of the Site may have new or modified uses, such as areas where groundwater collection or water treatment systems operate, and disposal areas for treatment system residues.

The Agencies anticipate that Holden Village will continue to occupy the former company town under a Special Use Permit from the Forest Service, during and after implementation of the cleanup action.

The Agencies anticipate that the National Forest portion of the Site and adjacent National Forest System land will continue to be managed as part of the National Forest following implementation of the remedy, including the Glacier Peak Wilderness, which generally bounds the Site to the west, north, and south. The Railroad Creek valley has historically provided habitat to spotted owls, lynx, grizzly bears, gray wolves, and other potentially threatened or endangered species, although no threatened or endangered species have been observed at the Holden Mine Site (personal communication, M. Lenz, Forest Service).

The Agencies expect the Railroad Creek Watershed will continue to be occupied by a hundred or fewer permanent residents, along with seasonal visitors on the order of 5,000 to 10,000 persons each year.

6.3 Surface Water and Groundwater Uses

The beneficial uses of groundwater at the Site are as a potential source of drinking water for residents and visitors, and as a source of recharge to local surface water bodies including Railroad Creek. Groundwater at and near the mine is not currently used for drinking water for residents and visitors, who get their drinking water from Copper Creek upstream of the Site. Groundwater is used as a source of drinking water at Lucerne, which is downgradient of the mine. Lucerne is considered part of the Site, since hazardous substances in Railroad Creek that exceed cleanup levels extend the entire way to Lake Chelan.

Groundwater also discharges to local surface water bodies, including Railroad Creek.

The designated beneficial uses of surface water (i.e., Railroad Creek) are aquatic life (salmonid spawning, rearing, migration, and core summer habitat), recreation (extraordinary primary contact), water supply (domestic, industrial, agricultural, and stock watering), and miscellaneous (wildlife habitat, harvesting, commerce and navigation, boating, and aesthetic value) [see WAC 173-201A-600].

The Site consists of lands that are administered by the Forest Service in accordance with the Forest Plan (Forest Service 1990 as amended), except for a limited area of about 235 acres that are patented mining claims owned by Holden Village. Since 1961, Holden Village has operated on National Forest System land under a Special Use Permit issued by the Forest Service, and on Holden Village land. Holden Village obtains its drinking water from Copper Creek upstream of the area impacted by releases from the mine. As a result, anticipated future uses of surface water and groundwater at the Site are expected to be the same as the current uses.

7.0 SUMMARY OF RISKS

This section provides a summary of human health and ecological risks at the Site. It also identifies the basis for taking action at the Site.

The major sources of information used to assess site risks due to contaminants of potential concern (COPCs) include the Draft Remedial Investigation Report (Dames & Moore 1999), U.S. Fish and Wildlife Service documents (USFWS 2004, 2005, and 2007a), the SFS (Forest Service 2007), and the Terrestrial Ecological Evaluation Report (ERM 2008 and 2009). Information from these sources was used to identify contaminants of concern (COCs) and develop risk-based cleanup levels (CULs) using risk-based published standards and site-specific, risk-based calculations, as appropriate.

7.1 Overview of Risk Assessment and Cleanup Level Process

This overview provides a road map of the risk assessment and cleanup level process used in this ROD. This process follows the Washington State MTCA cleanup regulation paradigm for developing cleanup standards (Chapter 173-340 WAC) and identifying risks. This process involves comparisons of media concentrations to risk-based concentrations (RBCs) to characterize Site risks. The scientific approach for deriving the MTCA RBCs is virtually identical to the

baseline risk assessment methodology described in CERCLA guidance (e.g., Risk Assessment Guidance for Superfund [EPA 1989]). For example, the MTCA Method B levels (i.e., RBCs) for the protection of human health use the same exposure factors and toxicity values as used in a baseline risk assessment performed using the EPA guidance.

The risk assessment and cleanup selection process used at this Site involves the following steps:

- The first step is the identification of contaminants of potential concern (COPCs). COPCs are constituents that may pose unacceptable risk to human health or the environment.

- The second step is the identification of COCs. COCs are hazardous substances that pose unacceptable risks to human health or the environment. COCs are identified as constituents with concentrations in site media (soil [including natural soil, mine tailings, and waste rock], groundwater, surface water, and sediment) that exceed the RBCs protective of human health and/or the environment and the background concentration.

- The final step of the process is the derivation of cleanup levels (CULs). The CUL is the higher of the RBC or background concentration because the CUL cannot be set at a concentration below background.[7]

These steps are described in the following subsections.

7.1.1 Identification of Contaminants of Potential Concern

The SFS (Forest Service 2007) identified COPCs for the Site, which were subsequently refined in the ASFS (Forest Service 2010a). COPCs were identified by comparing constituent concentrations measured in environmental media (i.e., soil and/or mine tailings, groundwater, surface water, and sediment) to chemical-specific criteria. These criteria are primarily RBCs selected to be protective of human health and the environment. For example, the criteria for soil include MTCA Method B levels protective of human health via the soil ingestion and dermal contact pathways, as well as protection of human health via the ingestion of groundwater pathway (see Table 8 in Forest Service 2007). The MTCA

[7] These cleanup levels were used as the screening levels referred to in Section 5.3.

Method B levels for human health were derived using exposure factors and toxicity values (carcinogenic and non-carcinogenic) protective of unrestricted land use. The screening levels used to identify COPCs were also used to identify COCs and, ultimately, were used in the selection of CULs.

7.1.2 Derivation of Risk-based Concentrations

The RBCs were developed for each environmental media of concern (i.e., groundwater, surface water, sediment, and soil) to be protective of human health and the environment.

Human health RBCs for groundwater are the lowest chemical-specific criteria shown in Table 2. The criteria include federal and state Maximum Contaminant Levels (MCLs), non-zero MCL Goals (MCLGs), and state MTCA Method A and B levels for the drinking water pathway. These criteria are risk-based and were developed using exposure factors and toxicity values protective of public consumption of drinking water. Although ecological receptors are not expected to be directly exposed to constituents in groundwater, aquatic receptors (e.g., fish, aquatic invertebrates) would be exposed to groundwater that discharges to surface water. Where this occurs, the surface water RBCs (i.e., chemical-specific criteria) listed in Table 3 also apply to groundwater.

RBCs for surface water are the criteria shown as the lowest chemical-specific criteria for the protection of human health and the environment shown in Table 3. These include federal and state surface water quality standards and criteria, MTCA Method B levels, and MCLs for drinking water which are risk-based. For example, state and federal water quality standards/criteria for protection of aquatic organisms are based on results of laboratory toxicity tests on a large number of different organisms (e.g., fish, aquatic invertebrates, amphibians, algae) that ensure the protection of aquatic organisms. Exposure pathways addressed by these RBCs include direct contact by aquatic organisms and human ingestion of water and aquatic organisms that accumulate constituents from water.

The sediment RBCs were the lowest chemical-specific criteria based on TBCs shown in Table 11 of the Proposed Plan. The criteria listed in that table are risk-based concentrations derived from toxicity test studies conducted primarily on aquatic invertebrates. These aquatic invertebrates typically live on or in the sediment and, therefore, are highly exposed to constituents in the sediment. Exposure pathways addressed by the criteria include direct contact and ingestion of sediment by aquatic organisms.

Human health RBCs for soil were developed using MTCA methods for three pathways: soil ingestion only, soil ingestion and dermal contact, and protection of groundwater (Table 9). The MTCA Method B levels were derived using standard formulas, exposure factors, and toxicity values (both carcinogenic and non-carcinogenic) protective of unrestricted (i.e., residential) land use. The standard Method B procedures use an acceptable cancer risk level of 1 in 1,000,000 and an acceptable hazard quotient (HQ) of 1 for non-carcinogens.[8] MTCA Method A levels (Table 9) were used as the human health-based soil RBC when a Method B level was unavailable, which only occurred for lead and petroleum hydrocarbon compounds.

Ecological RBCs for soil are identified in Appendix E of the ASFS (Forest Service 2010a). These RBCs are protective of three broad groups of ecological receptors: plants, soil invertebrates, and wildlife (e.g., birds and mammals). The RBCs for plants and soil invertebrates generally came from two published sources: MTCA ecological indicator soil concentrations (EISCs) (Table 749-3 of MTCA) and EPA's ecological soil screening levels (Eco-SSLs).[9] The EISCs and Eco-SSLs for plants and soil invertebrates were derived from published toxicity studies on a variety of test species; are assumed to be protective of all species in each of these groups; and address the direct contact pathway for plants and direct contact/soil ingestion pathways for soil invertebrates. In addition to the EISCs and Eco-SSLs, soil RBCs for several constituents were developed using site-specific information. Site-specific RBCs were developed for:

- Plants, for aluminum, copper, lead, molybdenum, and thallium; and
- Soil invertebrates, for copper and mercury.

Wildlife RBCs for soil were primarily developed using site-specific data (i.e., concentrations of contaminants in tissue from plant and soil invertebrates collected from the Site) and exposure models for six surrogate species: the vole, hare, deer, shrew, robin, and grouse. These six species represent different feeding guilds (i.e., herbivores and insectivores) that are highly exposed to soil

[8] The MTCA acceptable hazard quotient (HQ) of 1 is equivalent to EPA's acceptable hazard quotient, and the MTCA acceptable cancer risk level of 1 in 1,000,000 falls within EPA's acceptable risk range of 1 in 1,000,000 to 1 in 10,000 (see EPA OSWER Directive 9355.0-30).

[9] Available online at http://www.epa.gov/ecotox/ecossl/.

contaminants. Therefore, it is assumed that if these surrogate species are not at risk, wildlife (e.g., all birds and mammals) in general are protected. The exposure parameters and toxicity values used to derive the wildlife RBCs primarily came from MTCA (Table 749-5) and EPA's Eco-SSLs. Since plant and soil invertebrate tissue samples were not collected from the Lagoon, Maintenance Yard, or Ventilator Portal Surface Water Retention Area, it was not possible to derive site-specific wildlife RBCs for these AOIs. For these three areas, MTCA default wildlife EISCs were used as the RBCs. The wildlife RBCs address two exposure pathways: ingestion of soil and ingestion of plants or soil invertebrates that accumulate constituents from soil.

7.1.3 Identification of Contaminants of Concern

In general, COCs for each media and area of concern were identified by comparing media constituent concentrations from the Site to the RBCs (see Section 7.1.2) and background concentrations, when available. As described later in this subsection, several additional factors were also considered in the identification of soil COCs for terrestrial ecological receptors at several AOIs.

Groundwater COCs protective of humans drinking groundwater are identified in Table 4. Since ecological RBCs and background concentrations are not available for Site groundwater, the COCs shown in Table 4 were selected by comparing the 95 percent upper confidence level (95 UCL) constituent concentrations from each area of interest for the spring and fall periods to the human health RBC. COCs for the protection of groundwater discharging to surface water can be identified by comparing the Site concentrations shown in Table 4 to the RBCs protective of surface water receptors shown in Table 3.

Surface water COCs are identified in Table 5. These COCs were identified by comparing the 95 UCL constituent concentrations from samples collected in the spring and fall from five locations on Railroad Creek and two locations on Copper Creek to RBCs and background concentrations shown in Table 3. These RBCs are protective of aquatic organisms (e.g., fish, aquatic invertebrates, algae) and human consumption of water and organisms that accumulate constituents from the surface water.

Sediment COCs are identified in Table 6. These COCs were identified by comparing detected constituent concentrations at each sediment sampling location to the RBCs listed in Table 11 of the Proposed Plan. The ecological RBCs listed in Table 11 of the Proposed Plan were used to identify COCs.

Bioassays will be required in the future to confirm whether concentrations of COCs in sediment at the Site are protective (see Ecology 2011).

Human health-based COCs for soil are identified in Table 10. These COCs were identified by comparing the 95 UCL constituent concentration for each area of interest to the human health RBCs and background concentrations shown in Table 9.

Soil COCs for the protection of terrestrial ecological organisms were identified by first comparing COPC concentrations at each AOI to ecological RBCs. (Identification of COPCs is described above in Section 7.1.2). Those COPCs having HQs of one or less and/or whose concentrations did not exceed background levels (shown in Table 9), were not carried forward as COCs. In response to comments received on the Proposed Plan, the Agencies further refined the resulting list of COCs for several AOIs where additional data were available. These AOIs were the Wind-blown Tailings Area, Holden Village, the Ballfield Area, Honeymoon Heights Waste Rock Piles, the Areas Downslope from the Honeymoon Heights Waste Rock Piles, and the Lower West Area-East. The Agencies' additional evaluation involved comparison of plant and invertebrate tissue concentrations to tissue-based TRVs (presented in the ASFS) and to tissue background concentrations (presented in ERM 2009). Constituents whose concentrations in tissue did not exceed tissue-based TRVs and/or tissue background concentrations were not carried forward as COCs. The Agencies' evaluation also took into account the role of pH in the toxicity of aluminum. At AOIs where soil pH exceeded 5.5, aluminum was not carried forward as a COC because of its decreased toxicity. The Agencies' additional evaluation of COCs is detailed in Houkal and Dagel (2011). The final list of soil COCs for the protection of terrestrial ecological organisms is shown in Table 11.

7.1.4 Derivation of Cleanup Levels

Table 11 presents the CULs for groundwater, surface water, and soil. CULs were identified by first selecting the lower of the human health and ecological RBCs, when both are available. If the selected RBC protective of human health and the environment is above the background concentration, the CUL is the RBC. If the RBC is less than the background concentration, the CUL is set to the background concentration.

Table 11 does not list numeric CULs for sediment because the protectiveness of the remedy will be determined based on sediment bioassay results.

7.1.5 Examples of Cleanup Level Derivation and Risk Characterization

Four examples are provided below showing how the CULs identified in Table 11 were derived and how exceedances of these CULs relate to quantitative measures of risk. These examples include CULs for soil, groundwater, and surface water (Table 11).

The first step of the CUL derivation process is the selection of an RBC protective of human health and the environment. The lowest human health and ecological RBCs is the final RBC. In the second step of the process, the final RBC is compared to the background concentration and the higher of the two concentrations is selected as the CUL.

Example 1. Arsenic in soil at the Areas Downslope of Honeymoon Heights

- Step 1. Select RBC
  - The human health RBC is 0.62 mg/kg (Table 9).
    - This RBC is the MTCA Method B level for soil ingestion and dermal contact. Arsenic is a carcinogen and the Method B target risk is 1 in 1,000,000. The 95 UCL for arsenic in soil at the Areas Downslope of Honeymoon Heights is 20 mg/kg (Table 10), so the cancer risk is 1 in 68,000. Therefore, there is an unacceptable health risk from arsenic.
  - The ecological RBC is 18 mg/kg (ASFS Table 9, Forest Service 2010a).
    - This RBC is the lowest of the RBCs for plants (18 mg/kg), soil invertebrates (60 mg/kg), and wildlife (132 mg/kg). The 95 UCL for arsenic in soil is 20 mg/kg (Table 10), so the HQs are 1 plants, 0.3 invertebrates, 0.2 wildlife (Table 12). Therefore, there is no unacceptable ecological risk from arsenic.
  - The final RBC is 0.62 mg/kg.
- Step 2. Identify CUL
  - Areas Downslope of Honeymoon Heights is riparian habitat, with a background concentration of 16 mg/kg (Table 9).
  - Since the RBC is below background, the CUL is set at the background concentration of 16 mg/kg (Table 11).

Example 2. Copper in soil at Tailings Piles 1, 2, and 3

- Step 1. Select RBC
  - The human health RBC is 2,700 mg/kg (Table 9).
    - This RBC is the MTCA Method B level for soil ingestion and dermal contact. Copper is a non-carcinogen and the Method B target HQ is 1. The 95 UCL is for copper in soil at Tailings Piles 1, 2, and 3 is 865

mg/kg (Table 10), so the HQ is 0.32. Therefore, there is no unacceptable human health risk from copper.

- The ecological RBC is 85 mg/kg (ASFS Table 9) (Forest Service 2010a).
  - This RBC is the lowest of the RBCs from among plants (113 mg/kg), soil invertebrates (85 mg/kg), and wildlife (208 mg/kg). The 95 UCL for copper is 865 mg/kg (Table 10), so the HQs are 8 plants, 10 inverts, and 4 wildlife (Table 12). Therefore, there is an unacceptable risk to plants, invertebrates, and wildlife from copper.
- The final RBC is 85 mg/kg.

■ Step 2. Identify CUL

- Tailings Piles 1, 2, and 3 are mixed conifer habitat with a background concentration of 45 mg/kg (Table 9).
- Since the RBC is above background, the CUL is set at the RBC of 85 mg/kg (Table 11).

Example 3. Zinc in groundwater at the East and West Waste Rock Piles

■ Step 1. Select RBC

- The human health RBC is 4,800 ug/L (Table 2).
  - This RBC is the MTCA Method B level for drinking water. Zinc is a non-carcinogen and Method B target HQ is 1. Concentrations of zinc in groundwater are 9,270 ug/L in spring and 8,960 ug/L in fall (Table 4), so the HQs are 2 for spring and fall. Therefore, there is unacceptable health risk from zinc.
- The ecological RBC is 13.6 ug/L (Table 3). Concentrations of zinc in groundwater are 9,270 ug/L in spring and 8,960 ug/L in fall (Table 4), so the HQs would be roughly 700 for spring and fall. Therefore, there would be unacceptable risk to aquatic organisms from zinc should groundwater discharge to surface water at these concentrations.
- The final RBC is 4,800 ug/L for groundwater not entering surface water and 13.6 ug/L for groundwater entering surface water.

• Identify CUL

- The background level for zinc in surface water is 9.8 ug/L.
- The CUL is the higher of the RBC or background and is set at 4,800 ug/L for groundwater used as drinking water and 13.6 ug/L for groundwater entering surface water (Table 11).

Example 4. Aluminum in surface water in Railroad Creek

■ Step 1. Select RBC

- A human health RBC is not available (Table 2).
- The ecological RBC is 87 ug/L (Table 3).

  - This RBC is the chronic state water quality standard and is intended to be protective of aquatic organisms. Surface water concentrations at several locations on Railroad Creek have aluminum concentrations above the RBC (Table 5). The maximum aluminum concentration in surface water samples from Railroad Creek is 246 ug/L (Table 5), which equates to a HQ of 3. Therefore, there is unacceptable ecological risk from aluminum.
- The final RBC is 87 ug/L.

- Step 2. Identify CUL
  - The background concentration is 152 ug/L (Table 3).
  - Since the RBC is below background, the CUL is set at the background concentration of 152 ug/L (Table 11).

7.2 Human Health Risk

Humans potentially exposed to hazardous substances at the Site include Holden Village residents and visitors, other visitors to the National Forest, cleanup workers, and Agencies personnel. Table 1 presents a summary of the COCs including the minimum and maximum detected concentrations in different media at the Site, and the exposure point concentration, based on the 95 UCL.

Important exposure pathways by which humans may become exposed to hazardous substances at the Site include:[10]

- Ingestion of and dermal contact with soil; and
- Ingestion of groundwater.

7.2.1 Soil

Table 9 presents chemical-specific criteria and background concentrations for soil that were used to derive cleanup levels. Soil COCs include twelve metals, arsenic, and three petroleum hydrocarbon mixtures. Reasonable maximum

[10] Inhalation of airborne contaminants is not considered an important exposure pathway under existing conditions. Data from an air quality study conducted by the Forest Service in 1994 indicated that concentrations of airborne COPCs were well below EPA risk-based concentrations and that no additional air monitoring was required to address this pathway (Tetra Tech 1996).

exposure point concentrations of COCs in soil for areas of interest are shown in Table 10.

Soil concentrations of arsenic, cadmium, copper, lead, zinc, gasoline- and diesel-range hydrocarbons, and/or heavy oil-range hydrocarbons at some areas of interest exceed soil levels protective of human health from direct contact or ingestion. These areas include the Honeymoon Heights Waste Rock Piles and areas downslope; the Lower West Area, including soil in the Lagoon Area; and the Holden Village Maintenance Yard.

Soil concentrations of arsenic, cadmium, copper, mercury, selenium, silver, thallium, zinc, gasoline- and diesel-range hydrocarbons, and/or heavy oil-range hydrocarbons in some areas of interest also exceed soil levels protective of groundwater potentially used as a drinking water source. These areas include the areas listed above, as well as the tailings piles, main waste rock piles, and the Ventilator Portal Surface Water Retention Area.

7.2.2 Groundwater

Table 2 presents chemical-specific criteria and background concentrations for groundwater that were used to derive cleanup levels for protection of human health. As mentioned above in Section 7.1.2, these criteria include federal and state MCLs, non-zero MCL Goals (MCLGs), and state MTCA Method A and B levels for the drinking water pathway. Groundwater COCs include aluminum, cadmium, copper, lead, and zinc. Reasonable maximum exposure point concentrations for groundwater COCs in areas of interest are shown in Table 4.

Concentrations of aluminum, cadmium, copper, lead, and/or zinc in groundwater exceed cleanup levels for protection of human health in the Honeymoon Heights Waste Rock Piles, Mine Portal discharge, Lower West Area, East and West Waste Rock Piles, former Mill Building, and Tailings Piles.

7.3 Ecological Risks

Ecological receptors at the Site include aquatic organisms in Railroad Creek and terrestrial organisms, including plants, soil invertebrates, and wildlife.

Endangered Species Act (ESA)-listed threatened or endangered species including bull trout, Canada lynx, gray wolf, grizzly bear, marbled murrelet, northern spotted owl, showy stickseed, Wenatchee Mountains checker-mallow, and Ute ladies' tresses occur—or may occur—in Chelan County. Portions of Chelan

County are designated as critical habitat for bull trout, Canada lynx, Northern spotted owl, and Wenatchee Mountains Checkermallow. In addition, several USFWS candidate species or Species of Concern (USFWS 2010) are also present in the Railroad Creek valley, including wolverine, bald eagle, northern goshawk, Western gray squirrel, and Westslope cutthroat trout. The Railroad Creek valley has historically provided habitat to spotted owls, lynx, grizzly bears, gray wolves, and other potentially threatened or endangered species, although no threatened or endangered species have been observed at the Holden Mine Site (personal communication, M. Lenz, Forest Service). Table 1 presents a summary of the COCs including the minimum and maximum detected concentrations in different media at the Site, and the exposure point concentration, based on the 95 UCL. Table 13 presents a summary of the ecological exposure pathways of concern.

Important exposure pathways by which ecological receptors may become exposed to hazardous substances at the Site include:

- Ingestion of plants and soil invertebrates by wildlife;
- Dermal contact with soil by plants and invertebrates; and
- Ingestion of soil by soil invertebrates and wildlife.

Potential ecological risks at the Site are summarized in the following subsections.

7.3.1 Surface Water

Table 3 presents chemical-specific criteria and background concentrations for surface water that were used to derive cleanup levels for protection of aquatic receptors. Reasonable maximum exposure point concentrations of COCs in surface water collected from Railroad Creek and at the confluence of Copper Creek with Railroad Creek are shown in Table 5.

Surface water COCs include aluminum, cadmium, copper, iron, lead, and zinc. Concentrations of COCs exceed the surface water criteria that are protective of aquatic biota.

Risks for trout exist in surface water at the Site, primarily from dissolved copper, based on HQs for dissolved copper in surface water samples that ranged from 18 to 26 (Dames & Moore 1999). In addition, based on published scientific studies cited in USFWS (2004 and 2005), surface water concentrations of aluminum, cadmium, copper, and zinc exceed levels known to be toxic to trout

and other salmonids. Iron concentrations in surface water at the Site also have adverse effects on both fish and benthic macroinvertebrates (USFWS 2005).

7.3.2 Sediment

There currently are no promulgated federal or state freshwater sediment standards applicable to the Site. Proposed risk-based screening levels for sediment were presented in the Proposed Plan based on documents prepared by Ecology and others (Michelsen 2003; USACE et al., 2006; Ingersoll et al., 1996; Persaud et al., 1993; and Cubbage et al., 1997). Based on comparison to these screening levels, COCs for sediment include aluminum, beryllium, cadmium, chromium, copper, iron, and zinc, as shown in Table 6.

7.3.3 Soil

A summary of terrestrial ecological HQs for each COC in soil at the Site is presented in Table 12. HQs were calculated by dividing the reasonable maximum exposure point concentrations of COCs in soil (see Table 8) by the ecologically protective risk-based soil concentrations that are presented in the final Feasibility Study (see Appendix E of the ASFS).

- Risks for plants and soil macroinvertebrates result from hazardous substance concentrations in soil in almost all areas of the Site, with HQ values ranging to more than 100.

- Birds and mammals may be subject to toxicity effects from feeding in Site areas where the highest hazardous substance concentrations were measured (where HQs ranged to more than 100).

The following subsections describe risks shown in Table 12 for each area of interest.

Tailings Piles 1, 2, and 3

The tailings piles have concentrations of copper and zinc that produce HQs greater than 1 for plants and soil invertebrates. HQs for cadmium, copper, thallium, and zinc range from 4 to 40 for wildlife species (i.e., vole, shrew, hare, deer, robin, and grouse). Tailings are a source of risk to aquatic receptors (e.g., fish and invertebrates) through the soil to groundwater to surface water pathway, and where reactive tailings are released into Railroad or Copper Creeks through erosion or slope instability.

East and West Waste Rock Piles

Waste rock in the East and West Waste Rock Piles has concentrations of copper, lead, molybdenum, and zinc that produce HQ values greater than 1 for plants and/or soil invertebrates. HQs for barium, chromium, copper, lead, molybdenum, thallium, and zinc range from 2 to 60 for wildlife species. (i.e., vole, shrew, hare, deer, robin, and grouse).

Honeymoon Heights Waste Rock Piles

The waste rock in the Honeymoon Heights Waste Rock Piles has concentrations of various hazardous substances that produce HQ values greater than 1 for plants and soil invertebrates. HQs for barium, copper, lead, molybdenum, silver, and thallium range from 2 to 200 for wildlife species (i.e., vole, shrew, hare, deer, robin, and grouse).

Areas Downslope from the Honeymoon Heights Waste Rock Piles (DSHH)

The DSHH has concentrations of various hazardous substances that produce HQ values greater than 1 for plants[11] and soil invertebrates. HQs for aluminum, barium, copper, and thallium range from 2 to 70 for wildlife species (i.e., vole, shrew, hare, deer, robin, and grouse).

Ballfield Area

Soil at the Ballfield Area has concentrations of copper that produce an HQ value of 2 for soil invertebrates.

Holden Village

Soil at Holden Village produces HQs of 3 to 4 for plants and wildlife (i.e., vole, shrew, robin, and grouse)from aluminum, HQs of 2 for plants and invertebrates from copper, and an HQ of 2 for invertebrates from zinc.

[11] Recent analysis of site-specific plant tissue data (Houkal and Dagel 2011) showed that for copper, only, the conifer and grass plant groups are at risk.

Lower West Area

Soil in the Lower West Area-East has HQs for plants[12], soil invertebrates, and wildlife species (i.e., vole, shrew, hare, deer, robin, and grouse) for several contaminants ranging from 2 to 100.

Soil in the Lower West Area-West (other than the Lagoon Area) does not have HQs greater than 1 for terrestrial ecological receptors (i.e., plants, soil biota, and wildlife).

Lagoon Area

Soil within the Lagoon Area has HQs for a number of contaminants (including petroleum hydrocarbons) of 2 to over 100 for plants, soil invertebrates, and wildlife species.

Wind-Blown Tailings Area

Soil within the Wind-Blown Tailings Area produces an HQ of 3 for plants from molybdenum.

Maintenance Yard

Soil at the Maintenance Yard has concentrations of hazardous substances that produce HQs for a number of contaminants (including petroleum hydrocarbons) of 2 to over 100 for plants, soil invertebrates, and wildlife species.

Former Mill Building

Soil in the former Mill Building area has not been characterized because of safety concerns associated with the derelict structure. Sources of contamination within the former Mill Building likely include unprocessed ore, mineral concentrates (processing residuals), and mineral salts present on the surface and in abandoned equipment. The presence of potential hazardous substances in

[12] Recent analysis of site-specific plant tissue data (Houkal and Dagel 2011) showed that for aluminum, only, the conifer and grass plant groups are at risk; for copper, only, the shrub plant group is at risk; and for molybdenum, only, the shrub and grass plant groups are at risk.

the former mill is inferred from groundwater seeps from the mill area that have concentrations of several hazardous substances above state and federal criteria for the protection of aquatic life, and cadmium and copper concentrations above drinking water criteria.

Ventilator Portal Surface Water Retention Area

Soil within the Ventilator Portal Surface Water Retention Area has HQs for aluminum, barium, copper, and zinc of 2 to over 100 for plants, soil invertebrates, and/or wildlife species.

7.4 Basis for Action

Contamination at the Site presents an unacceptable risk to human health and the environment. Human receptors may be harmed by exposure to hazardous substances present in soil that pose risks in excess of a HQ of 1 and in groundwater above the MCLs for cadmium, copper, and lead. Terrestrial and aquatic ecological receptors may be harmed by exposure to hazardous substances in soil, surface water, sediment, and groundwater that discharges into surface water above levels that are protective of terrestrial and aquatic life, with some metals posing potential ecological risks significantly higher than an HQ of 1 (HQs are as high as 700 for zinc). The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

A situation that may present an imminent and substantial endangerment to human health and the environment exists at the Site because of the risks from and continuing releases of hazardous substances, including:

- Tailings and waste rock (ARD) and the mine (AMD) contribute to low pH and high metals content in groundwater and surface water that causes significant contamination within the Site.

- Concentrations of hazardous substances in groundwater exceed human health-based criteria for drinking water in some portions of the Site;

- Groundwater containing concentrations of hazardous substances is above levels protective of fish and benthic macroinvertebrates, discharges into surface water;

- Where groundwater discharges to surface water, concentrations of hazardous substances in seeps and pore water discharging into Railroad Creek are above levels protective of fish and benthic macroinvertebrates;

- Concentrations of hazardous substances in surface water (Railroad Creek and the Copper Creek Diversion) are consistently above levels protective of aquatic health (fish and benthic macroinvertebrates);

- High concentrations of hazardous substances present in pore water, surface water, and sediment have reduced the populations of fish and benthic macroinvertebrates in Railroad Creek adjacent to and downstream of the mine, and have also impacted sediment at the Lucerne Bar;

- Concentrations of hazardous substances in mine tailings, waste rock, and soil at the Site exceed criteria for protection of human health, including direct contact and ingestion, and criteria for protection of the environment; and

- Tailings pile slope instability from an earthquake event or erosion presents a risk of additional hazardous substances being released into Railroad and Copper Creeks.

8.0 REMEDIAL ACTION OBJECTIVES

Proposed remedial action objectives (RAOs) have been articulated by both the Agencies and Intalco since the late 1990s. RAOs provide a general description of the goals of the overall cleanup. RAOs have been developed for protection of human health and ecological receptors. The Agencies first presented the RAOs in draft form to summarize the Agencies' goals and expectations for remedial work to address the ongoing release of hazardous substances, restore natural resources, and protect human health and the environment. (Forest Service 1999). The Agencies revised the draft RAOs as new information about the Site was developed, as provided in 40 C.F.R. § 300.430(e)(2)(i).

8.1 Remedial Action Objectives

The RAOs for the Holden Mine Site are as follows:

1. Reduce concentrations of contaminants of concern to levels that are protective of aquatic life and comply with applicable, or relevant and appropriate requirements (ARARs) in Railroad Creek and other surface waters.

2. Reduce exposure to contaminants of concern in sediment, (including the adverse effects of ferricrete on aquatic life in Railroad Creek) to protect aquatic life and comply with ARARs.

3. Prevent migration of contaminants of concern that exceed cleanup levels in groundwater (including the Main Portal discharge) from on-site waste management areas (WMAs), to protect aquatic life and comply with ARARs.

4. Reduce exposure to contaminants of concern in soil (including tailings and other wastes) to protect terrestrial organisms and comply with ARARs. Prevent future releases of tailings and other wastes into surface water to protect aquatic receptors from contaminants of concern.

5. Protect human health and comply with ARARs by reducing human exposure to contaminants of concern in soil and other wastes, controlling exposure to contaminated groundwater, and by restoring groundwater beyond the WMAs to its beneficial use as a drinking water resource.

6. Implement the remedial action in a manner that complies with ARARs and protects human health, welfare, and the environment, including the Holden Village residential community during and after construction.[13]

8.2 Basis for RAO Selection

The RAOs were selected to summarize the Agencies' goals and expectations for remedial work to significantly reduce the release of hazardous substances and protect the environment. The RAOs include improvement of surface water and sediment quality to protect aquatic receptors, cleanup of hazardous substances

[13] The Agencies understand that Holden Village has concerns for the viability of its operations in the event that remedial construction results in substantial curtailment of the Village's normal activities for more than 2 consecutive years, or a second curtailment within 5 years of the first construction period. The Agencies will strive to achieve a schedule and other aspects of the remedy that are consistent with the expressed preferences of Holden Village. Circumstances may interfere with achieving this goal, however. The Agencies have taken into account Holden Village's request for a 5-year gap between the conclusion of the first and beginning of the second phases of major construction, as described in this ROD.

in soil to protect human health and terrestrial organisms, and the cleanup of groundwater.

An important aspect of the Selected Remedy is addressing groundwater that is contaminated with hazardous substances. As discussed in Section 6.3, one of the beneficial uses for groundwater at the Site is as a potential source of drinking water. As a result, Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act are relevant and appropriate standards for groundwater cleanup.

In accordance with Section 121(d)(2)(A) of CERCLA [42 U.S.C. § 9621(d)(2)(A)], and the NCP, groundwater at the Site must be restored to meet MCLs. The NCP provides that groundwater will be returned to its beneficial uses (including MCLs) within a reasonable restoration time frame wherever practicable [40 C.F.R. § 300.430(a)(1)(iii)(F)]. Although the point of compliance for groundwater cleanup under CERCLA is generally throughout the contaminated plume[14], the NCP recognizes that remedies may involve areas where waste materials will be managed in place. Such areas are referred to as waste management areas (WMAs). As discussed in Section 2.5 of the ASFS, certain groundwater source areas at the Site will be WMAs once the remedy is implemented as shown on Figure 14. The Selected Remedy will contain and capture the groundwater within the WMA. The containment is necessary to prevent migration of the groundwater contamination that exceeds MCLs and to prevent groundwater from discharging to surface water above levels protective of receptors including aquatic life. WMA boundaries encompass the tailings piles, mill building, the main waste rock piles, and the Lower West Area that contains extensive areas of tailings. The tailings piles and the main waste rock piles will be capped, contained, and managed in accordance with ARARs (e.g., Washington's Limited Purpose Landfill regulations).

Groundwater may remain contaminated within a WMA, and cleanup levels attained at and beyond the edge of the WMA [55 Fed. Reg. 8712, 8753, March 8, 1990], so long as measures are taken to contain and prevent exposure to the contaminated groundwater, and restoration to beneficial uses remains the goal at and beyond the edge of the WMA. Therefore, the groundwater restoration RAOs do not include cleanup of groundwater to drinking water or surface water

[14] Similarly, MTCA generally requires that all groundwater throughout the Site achieve cleanup levels [WAC 173-340-720(8)(b)].

quality standards for the protection of aquatic life so long as groundwater is contained within WMAs at the Site.

Drinking water standards must be met at a point of compliance for groundwater which is at and beyond the boundary of the WMA. Without the remedy, groundwater will continue to discharge into surface water at concentrations that exceed levels protective of aquatic life.

In addition to being a potential source of drinking water, a beneficial use of groundwater at the Site is recharge to surface water to support aquatic life. Groundwater discharging through seeps, springs, or base flow that would otherwise adversely impact surface water must be managed for surface water protection.

Both CERCLA and MTCA seek to restore groundwater quality wherever practicable. CERCLA requires consideration of the state's stream classification for protection of site-specific uses that could be impacted by groundwater discharging into the surface water.[15] At a minimum, this includes preventing receptors in the creeks from being exposed to groundwater that exceeds aquatic life protection criteria and meeting drinking water standards by controlling hazardous substances before they enter the surface water (see the NCP preamble [55 Fed. Reg. 8713]).

Certain provisions of MTCA are ARARs under CERCLA. Under MTCA, a conditional POC for groundwater to meet ambient water quality standards must be as close as practicable to the source, and groundwater discharging to surface water must meet cleanup standards at or before the groundwater-surface water interface, with specific conditions that must be satisfied before a conditional POC may be established at the point(s) where groundwater enters surface water [WAC 173-340-720(8)(c)&(d)].

---

[15] In this case, the Washington State regulations [WAC 173-201A-200 and -600] require protection of Railroad Creek's and Copper Creek's designated beneficial uses. Per WAC 173-201A-600, the following are the designated beneficial uses of surface water at the Site (use categories in parentheses): aquatic life (salmonid spawning, rearing, migration, and core summer habitat), recreation (extraordinary primary contact), water supply (domestic, industrial, agricultural, and stock watering), and miscellaneous (wildlife habitat, harvesting, commerce and navigation, boating, and aesthetic value).

Based on the above, in the Selected Remedy: 1.) groundwater must meet MCLs at and beyond the boundary of the WMA, and 2.) groundwater cleanup levels must be achieved within groundwater before that portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates, and not simply in the surface water column after dilution has occurred. The cleanup standards that will be used to measure progress toward and compliance with the RAOs are discussed further in Section 7 and shown in Table 11.

9.0 DESCRIPTIONS OF ALTERNATIVES

This section summarizes the remedial alternatives considered by the Agencies. The alternatives that have been considered for the Site are:

- Alternatives 1 through 8 and associated sub-alternatives developed and evaluated by Intalco in the DFFS (URS 2004);
- Alternative 9, developed by Intalco (URS 2005);
- Alternatives 10, 11, and 12, developed by the Agencies and evaluated, along with Alternative 9, in the SFS (Forest Service 2007c);
- Alternative 13 was presented by Intalco (Intalco, October 2007), but was subsequently modified by Intalco and renamed Alternative 13M (ERM and URS 2009);
- Alternative 11M is a refinement of an earlier alternative, Alternative 11, which the Agencies modified in response to new information that was obtained by Intalco during its studies related to Alternative 13M; and
- Alternative 14 (the Preferred Alternative presented in the Proposed Plan), which the Agencies developed to address deficiencies in Alternative 13M. Alternatives 11M and 14 were evaluated, along with Alternative 13M, in the ASFS (Forest Service 2010b).

In considering alternatives developed for the Site, the Agencies first reviewed and considered whether the alternatives met the threshold requirements, which are the criteria specified in 42 U.S.C. § 9621(d), 40 C.F.R. § 300.430(f)(1)(i)(A) and WAC 173-340-360(2)(a) that must be satisfied for a remedial alternative to be selected as the final cleanup remedy for a site. The CERCLA threshold criteria for remedy selection are:

1) Overall protection of human health and the environment; and

2) Compliance with ARARs [except when an ARAR is waived, as allowed under 42 U.S.C. § 9621(d)(4), and 40 C.F.R. § 300.430(f)(1)(ii)(C)].

For Ecology's purposes, the threshold requirements for selecting a cleanup remedy under MTCA include that the remedy:

1) Protect human health and the environment;

2) Comply with cleanup standards;

3) Comply with applicable state and federal laws; and

4) Provide for compliance monitoring.

The DFFS presented Alternatives 1 through 8, including sub-alternatives. The Agencies' review of the DFFS concluded that Alternatives 1 through 8 did not meet the threshold criteria, based on information provided in the DFFS. In addition, the Agencies determined that the subsequent Alternatives 9 and 10 did not meet the threshold requirements.

Intalco presented Alternative 1 in the DFFS as a no-action alternative, but it included institutional controls and monitoring. The Agencies determined the alternative to be inconsistent with a no-action alternative. CERCLA requires a "no-action alternative" to be developed and considered in the analysis of the developed alternatives. Accordingly the Agencies developed Alternative 12 as a true "no-action" alternative for comparison purposes. The no-action alternative would leave the Site untouched and would not include institutional controls or long-term monitoring. Ongoing releases of hazardous substances would continue under this alternative. Existing risks caused by hazardous substances in soil, groundwater, and surface water would not be addressed except by source depletion and possibly natural attenuation that would occur gradually over a period of hundreds of years.

A summary description of Alternatives 1 through 10 is presented in Table 14. These alternatives and their sub-alternatives were not acceptable as a final remedial action (Forest Service 2007d); therefore, they were not carried forward and discussed in the comparative analysis of alternatives section of the Proposed Plan and are not formally evaluated in this ROD. Alternatives 11 and 13 were subsequently modified to 11M and 13M, respectively.

Alternatives 11M, 12 (No Action Alternative), 13M, and 14 were identified by the Agencies to be appropriate for comparison as final remedial actions and were evaluated as described in the Proposed Plan. These alternatives are described below in Section 9.1 and carried forward in their evaluation and the subsequent selection of the final remedial action selected in this ROD.

9.1 Description of Alternatives 11M, 12, 13M, and 14

The alternatives summarized in this section were carried forward and evaluated by the Agencies in the ASFS and the Proposed Plan. These alternatives were considered by the Agencies to be appropriate for comparison as a final remedial action at the Site. A comparative analysis of these alternatives is presented in Section 10 of this ROD. Table 15 provides a comparison of remedy components under Alternatives 11M, 13M, and 14.

Figures 15, 16, and 17 present the principal remedial components of Alternatives 11M, 13M, and 14, respectively. Remedy components that are common to Alternatives 11M, 13M, and 14 are discussed in Section 9.1.5.

Although the alternatives were developed with sufficient detail for evaluation and comparison, a number of design details remain that need to be determined during remedial design, including creek relocation, final slope grade and buttress design for the tailings piles, final waste rock slope grade, design of caps to isolate contaminated materials and protect plants and animals, final design of the groundwater treatment facilities, and *in situ* soil treatment (i.e., pH adjustment through lime application) where applicable.

9.1.1 Alternative 11M (Soil and Source Area Consolidation and Capping; Groundwater Collection and Treatment; Ferricrete Removal and Institutional Controls)

Estimated Capital Cost: $88,500,000

Estimated Average Annual O&M Costs: $640,000

Estimated Present Worth Costs: $120,000,000[16]

[16] Present worth costs are the total of capital cost and the net present value of long-term costs for operations, maintenance, and monitoring, in accordance with EPA guidance

Estimated Construction Timeframe: Three years (not including anticipated preliminary work).

Estimated Time to Achieve RAOs: Alternative 11M would protect human health and is anticipated to be protective of the environment shortly after the remedy is implemented.

Alternative 11M includes: consolidation and capping the tailings piles, waste rock piles and impacted soil; containment and collection for treatment of impacted groundwater from within designated WMAs; removal of ferricrete from Railroad Creek; *in situ* treatment by pH adjustment of some areas of impacted soil; and implementation of institutional controls.[17] Alternative 11M relies on the following treatment technologies: pH adjustment and precipitation for removal of metals from acid rock drainage; and pH adjustment to decrease the mobility and toxicity of some areas of impacted soils.

Alternative 11M would require institutional controls including a restrictive covenant on private property (e.g., the patented mining claims owned by Holden Village) and institutional controls on National Forest System land that the Forest Service will implement through the notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest. These institutional controls would be required for hundreds of years to:

- Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;

- Protect the integrity of the remedy by preventing changes in Site use that would reduce effectiveness of the remedy;

(EPA 2000). The costs presented in this ROD are shown in current (2010) dollars, rounded to three significant figures. The net present value for long-term costs was calculated using a discount rate of 7 percent and a period of 50 years.

[17] *In situ* treatment would consist of application of agricultural lime (or another neutralizing agent) to raise soil pH and thereby reduce the mobility and bioavailability of hazardous substances. The methods and rate of application would be determined by treatability tests during remedial design.

- Include a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective;

- Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;

- Prevent the potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;

- Provide for permanent access to privately owned land to monitor and maintain the remedy; and

- Implement possible administrative access restrictions to some portions of the Site.

The estimated total cost for implementing Alternative 11M is $120 million (net present worth, based on a discount rate of 7 percent and a period of 50 years). This includes the estimated capital cost of $88.5 million, and estimated operations, maintenance, and monitoring (OMM) costs that average about $640,000 per year.

The duration for construction of Alternative 11M is anticipated to be 3 years, as discussed in the SFS. Alternative 11M would achieve RAOs shortly after the end of construction (e.g., based on containment and capping hazardous substances, institutional controls, and natural attenuation of the groundwater plume downgradient of the groundwater containment barriers following elimination of the sources of groundwater contamination). Alternative 11M would require continued operation and maintenance of the water treatment system for groundwater within the WMAs for hundreds of years.

Alternative 11M would achieve all ARARs, in particular the remedy selection and cleanup standards defined in MTCA, the water quality criteria defined under the Clean Water Act (CWA), the Forest Plan, and Washington's Limited Purpose Landfill regulations; see Table 16 for a detailed breakdown.

The main remedial components of Alternative 11M are summarized below by media or AOI.

Soil and Sediment

The side slopes of Tailings Piles 1, 2, and 3 would be stabilized and the lower portions near Railroad Creek moved back to reduce erosion and releases of tailings into the creek. The Copper Creek Diversion and the Copper Creek channel would be modified to prevent future erosion and releases of tailings into surface water. After regrading, the tailings piles and the East and West Waste Rock Piles would be capped. Before capping, contaminated soil excavated from the Honeymoon Heights Waste Rock Piles and the impacted DSHH area would be consolidated with the tailings piles. Sediment in Railroad Creek would be remediated by excavating ferricrete from the creek bed.

Soil in the Lower West Area, the Wind-Blown Tailings Area, and in Holden Village would be remediated by both excavation and consolidation of soil with hazardous substances, and by *in situ* treatment. The combination of the excavation and consolidation and *in situ* treatment methods will be based on the degree of contamination, the function of the habitat, and the succession stage of the habitat to be remediated.

Soil exceeding cleanup criteria in the Maintenance Yard would be left in place and capped. Soil at the Lagoon Area and Surface Water Retention Area would be excavated and consolidated with the tailings prior to capping. An investigation would be accomplished during remediation design activities to determine the extent of waste rock contamination (if any) of the Lucerne-Holden Road. The results of the investigation would be used to develop a cleanup approach, if necessary.

Groundwater

A fully penetrating (i.e., keyed into a lower, relatively impermeable layer of glacial till or bedrock) groundwater containment barrier would be constructed along the downgradient side of the tailings piles and the Lower West Area to prevent ARD from discharging into Railroad Creek. The barrier and treatment system would hydraulically control and collect contaminated groundwater and seeps and protect surface water in Railroad Creek from the release of the groundwater and seeps that exceed aquatic protection standards.

Concentrations of hazardous substances in the Main Portal discharge would be reduced by reducing airflow through the mine, thus reducing the rate of oxidation of sulfide minerals within the mine. Groundwater discharging from the mine (AMD) would be collected and treated.

Surface Water

Surface water run-on would be controlled by constructing stormwater diversion swales and other measures upgradient from Tailings Piles 1, 2, and 3 and the East and West Waste Rock Piles. The diversion swales will reduce the run-on from upslope that could otherwise infiltrate into the tailings and waste rock piles and become contaminated. This will reduce the amount of contaminated groundwater that must be contained by the groundwater barrier walls that, along with flow from the mine and seeps downgradient of Honeymoon Heights, must be collected and conveyed to the treatment system. These actions would limit discharge of contaminants in groundwater above ARARs into Railroad Creek.

Former Mill Building

The Mill Building superstructure would be demolished. Soil exceeding cleanup levels at the former Mill Building would be excavated and consolidated with the tailings piles prior to capping or disposed of off site, depending on results of waste designation during remediation.

9.1.2 Alternative 12 (No-Action Alternative)

Estimated Total Project Cost per the ASFS: $0

CERCLA requires a "no-action alternative" to be developed and considered in the analysis of the developed alternatives. The no-action alternative would leave the Site untouched and would not include institutional controls or long-term monitoring. Ongoing releases of hazardous substances would continue under this alternative. Existing risks caused by hazardous substances in soil, groundwater, and surface water would not be addressed except by source depletion and possibly natural attenuation that would occur gradually over a period of hundreds of years.

Alternative 12 includes no actions to control exposure of ecological receptors to contaminants. Risks to fish and other aquatic receptors, and terrestrial receptors would continue for the foreseeable future.

9.1.3 Alternative 13M (Soil and Source Area Consolidation and Capping; Limited Groundwater Collection and Treatment; Isolation of Ferricrete by Stream Relocation, and Institutional Controls)

Estimated Capital Cost: $56,400,000

Estimated Average Annual O&M Costs: $470,000

Estimated Present Worth Costs: $79,800,000

Estimated Construction Timeframe: Two to three years (not including anticipated preliminary work).

Estimated Time to Achieve RAOs: Alternative 13M would protect human health but would not sufficiently protect terrestrial or aquatic organisms.

Alternative 13M includes: consolidation and capping the tailings piles, waste rock piles, and impacted soil; and containment and collection for treatment of impacted groundwater from a WMA that consists of the Lower West Area, main East and West Waste Rock Piles, and Tailings Pile 1 (but would not include containment and collection of impacted groundwater from Tailings Piles 2 and 3). Alternative 13M also includes relocation of Railroad Creek, which would eliminate the effects of ferricrete on aquatic habitat, and implementation of institutional controls. Alternative 13M relies on the following treatment technology: pH adjustment and precipitation for removal of metals from ARD.

Alternative 13M would require institutional controls, including a restrictive covenant on private property (e.g., the patented mining claims owned by Holden Village) and the notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest. These institutional controls would be required for hundreds of years to:

- Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;

- Protect the integrity of the remedy by preventing changes in Site use that would reduce effectiveness of the remedy;

- Include a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective;

- Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;

- Prevent the potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;

- Provide for permanent access to privately owned land to monitor and maintain the remedy; and

- Implement possible administrative access restrictions to some portions of the Site.

The estimated total cost for implementing Alternative 13M is $79.8 million (net present worth, based on a discount rate of 7 percent and a period of 50 years). This includes the estimated capital cost of $56.4 million, and estimated OMM costs that average about $470,000 per year.

The duration for construction of Alternative 13M is anticipated to be 2 to 3 years, as discussed in the ASFS. Alternative 13M would not achieve RAOs after the end of construction (e.g., it would not fully address the sources of contamination to groundwater, or the effects of hazardous substances on terrestrial receptors in some areas of the Site). Alternative 13M would require continued operation and maintenance of the water treatment system for groundwater within the WMA for hundreds of years. Alternative 13M would allow the continued release of groundwater above cleanup levels, from below Tailings Piles 2 and 3, for hundreds of years.

Alternative 13M would protect human health through containment and capping of hazardous substances, and institutional controls. Alternative 13M would not achieve all ARARs; specifically the remedy selection and cleanup standards defined in MTCA, the water quality criteria defined under the CWA, the Forest Plan, and Washington's Limited Purpose Landfill regulations, see Table 16 for a detailed breakdown.

The main remedial components of Alternative 13M are summarized below by media or AOI.

Soil and Sediment

Portions of the side slopes of Tailings Piles 1, 2, and 3 would be regraded to improve stability, and a portion of Railroad Creek would be relocated northward away from the tailings piles into a new channel. The relocation would isolate ferricrete from aquatic life in this reach of the channel. Relocating Railroad Creek would also enable construction of a groundwater barrier adjacent to a portion of the tailings piles without the need to excavate the tailings to move the toe of the slope away from the creek. The former creek channel would be used to collect groundwater impacted by seepage from the western portion of Tailings Pile 2, and to convey groundwater to a water treatment facility located east of Tailings Pile 3. The Copper Creek channel would also be modified to reduce the risk of erosion and scour on Tailings Piles 1 and 2.

After regrading, the tailings piles and East and West Waste Rock Piles would be capped with soil and vegetated. Excess rock generated from regrading would be relocated onto Tailings Pile 1 and the former Mill Building foundation. Before capping, contaminated soil excavated from the Lagoon Area would be consolidated with the tailings piles. Soil exceeding cleanup criteria in the Maintenance Yard would be left in place and capped with concrete or a gravel cap with an impermeable liner.

No remediation would be done to address contaminated soil from the Honeymoon Heights Waste Rock Piles and the impacted DSHH area, the Ballfield, the Lower West Area, or in Holden Village.

Groundwater

A fully penetrating (i.e., keyed into a lower relatively impermeable layer of glacial till or bedrock) groundwater containment barrier would be constructed along the downgradient side of Tailings Pile 1 and the Lower West Area to prevent ARD from part of the Site from discharging into Railroad Creek. Groundwater flowing from seeps downslope of Honeymoon Heights would also be collected. However, ARD from Tailings Piles 2 and 3 would not be contained or collected for treatment under Alternative 13M.

Hydraulic bulkheads would be installed in the mine to control and equalize the rate of groundwater discharging from the Main Portal. Concentrations of hazardous substances in the Main Portal discharge would be reduced by installing air restrictors in open portals to reduce air flow through the mine, thus reducing the rate of oxidation of sulfide minerals within the mine.

Groundwater discharging from the mine (AMD), the collected seeps, the Lower West Area, and Tailings Pile 1 groundwater containment area would be conveyed to treatment facilities located in the Lower West Area and east of Tailings Pile 3.

Surface Water

Surface water run-on would be controlled by constructing stormwater diversion swales and other measures upgradient from Tailings Piles 1, 2, and 3 and the East and West Waste Rock Piles.

Surface water impacts to Railroad Creek from groundwater are addressed in this alternative by: 1) relocating a portion of Railroad Creek to isolate ferricrete from the aquatic habitat; 2) using the former creek channel (before relocation) as a collection trench to collect and convey groundwater for treatment; and 3) using a hydraulic barrier placed around Tailings Pile 1 and the Lower West Area to stop discharge of contaminated groundwater (including seeps and discharge from the Main Portal). Erosion of the tailings into Railroad Creek would be prevented through regrading and capping to prevent future surface water impacts from physical transport of the tailings.

Former Mill Building

The Mill Building superstructure would be demolished; contaminated materials remaining within the Mill Building would be covered with waste rock, covered with soil cover, and re-vegetated.

9.1.4 Alternative 14 (Soil and Source Area Consolidation and Capping; Groundwater Collection and Treatment; Isolation of Ferricrete by Stream Relocation, *In Situ* Treatment, and Institutional Controls)

Estimated Capital Cost: $76,100,000

Estimated Average Annual O&M Costs: $615,000

Estimated Present Worth Costs: $107,000,000

Estimated Construction Timeframe: Two years preliminary work plus a total of 4 years of heavy construction (in two phases).

Estimated Time to Achieve RAOs: Alternative 14 would protect human health and is anticipated to be protective of the environment shortly after the remedy is implemented.

Alternative 14 includes: consolidation and capping the tailings piles, waste rock piles, and impacted soil; containment and collection for treatment of impacted groundwater from within designated WMAs; relocation of Railroad Creek to eliminate the effects of ferricrete on the aquatic environment; *in situ* treatment of some areas of impacted soil; and implementation of institutional controls. Alternative 14 relies on the following treatment technologies: pH adjustment and precipitation for removal of metals from ARD; and pH adjustment to decrease the mobility and toxicity of some areas of impacted soils.

Alternative 14 would require institutional controls including a restrictive covenant on private property (e.g., the patented mining claims owned by Holden Village) and the notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest. These institutional controls would be required for hundreds of years to:

- Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;
- Protect the integrity of the remedy by preventing changes in Site use that would reduce effectiveness of the remedy;
- Include a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective;
- Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;
- Prevent the potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;
- Provide for permanent access to privately owned land to monitor and maintain the remedy; and
- Implement possible administrative access restrictions to some portions of the Site.

The institutional controls would include signage to warn of human health risks in areas subject to long-term *in situ* treatment, such as portions of the Lower West Area, Honeymoon Heights Waste Rock Piles, and the impacted areas downslope of Honeymoon Heights Waste Rock Piles (DSHH).

The estimated total cost for implementing Alternative 14 is $107 million (net present worth, based on a discount rate of 7 percent and a period of 50 years). This includes the estimated capital cost of $76.1 million, and estimated OMM costs that average about $615,000 per year.

The duration for construction of Alternative 14 is anticipated to be about 6 years, including 2 years of early work, 2 years of heavy construction for Phase 1, and 2 years of heavy construction for Phase 2, as discussed in Section 4.1.[18] Alternative 14 would achieve RAOs shortly after the end of construction (e.g., based on containment and capping hazardous substances, institutional controls, and natural attenuation of the groundwater plume at and downgradient of the groundwater containment barriers following elimination of the sources of groundwater contamination). Although groundwater will continue to exceed cleanup levels downgradient of Tailings Piles 2 and 3 until shortly after the end of the second phase of construction, the first phase of the remedy will eliminate risks to human health and most terrestrial receptors (except in the wetland downgradient of Tailings Pile 3. Alternative 14 would require continued operation and maintenance of the water treatment system for groundwater within the WMAs for hundreds of years.

Alternative 14 would achieve all ARARs, in particular the remedy selection and cleanup standards defined in MTCA, the water quality criteria defined under the CWA, the Forest Plan, and Washington's Limited Purpose Landfill regulations (see Table 16 for a detailed breakdown).

---

[18] Construction schedules were not evaluated to the same level of detail for all alternatives considered in the final Feasibility Study. In particular, Alternatives 11M and 13M were developed without discussion of the concept of early work (e.g., road improvements, quarry and borrow source development, preparation of construction staging areas, and relocation of some of Holden Village's infrastructure) that were developed to reduce the duration of heavy construction. Alternative 14 and the Selected Remedy were planned to be completed in two stages of heavy construction separated by a period of 5 years, to reduce the impacts of construction on Holden Village.

The main remedial components of Alternative 14 are summarized below by media or AOI. Alternative 14 (referred to as the Preferred Alternative in the Proposed Plan) is the basis for the Selected Remedy.

Soil and Sediment

A portion of the Railroad Creek stream channel would be relocated northward into a new channel to enable construction of a groundwater barrier around the tailings piles, and to reduce the risk of scour causing instability of the tailings piles. The Copper Creek stream channel would be modified to reduce the risk of erosion and scour, and the toe of Tailings Piles 1 and 2 would be pulled back away from Copper Creek.

Relocation of Railroad Creek and construction of the groundwater barrier walls would eliminate the effects of ferricrete on aquatic habitat. The new channel would bypass the reach where ferricrete has been deposited. Groundwater, with dissolved contaminants (primarily ferric oxides and sulfates) that form ferricrete, would be prevented from discharging into the new creek channel.

The tailings piles and East and West Waste Rock Piles would be regraded so they are stable, capped, and vegetated. Excess waste rock generated from regrading would be consolidated onto the tailings piles. The tailings piles, main East and West Waste Rock Piles, and the Lower West Area would be designated as WMAs.

Soil exceeding cleanup levels in several areas of the Site would be excavated and consolidated into the tailings piles before capping. These areas include:

- Soil above cleanup levels from the Ventilator Portal Surface Water Retention Area, the Ballfield, and existing disturbed portions of the Lower West Area including the Lagoon Area (other portions of the Lower West Area would be treated *in situ*, to avoid extensive disturbance of high-quality riparian habitat.

- Soil above cleanup levels in other areas where excavations are needed for other components of the remedy, such as relocating Railroad Creek in the Wind-Blown Tailings Area or for excavation of settling ponds for the groundwater treatment facility.

Soil exceeding cleanup criteria in the Maintenance Yard would be left in place and capped. Soil exceeding cleanup levels in other AOIs would be remediated using *in situ* treatment to reduce the mobility and bioavailability of hazardous

substances where more active measures (i.e., consolidation and capping) is impracticable because of steep slopes, or would cause more adverse impacts than benefits. Examples of areas appropriate for *in situ* treatment include Holden Village and high-value, late successional habitat in portions of the Lower West Area, as noted above.

Finally, an investigation would be accomplished during remedial design to determine the extent of waste rock contamination (if any) of the Lucerne-Holden Road. The results of the investigation would be used to develop a cleanup approach if necessary.

Groundwater

A fully penetrating groundwater barrier wall would be constructed on the north, east, and west sides of the Lower West Area and Tailings Pile 1 to contain groundwater impacted by ARD. Groundwater contained in this area would be collected and conveyed to the treatment facility. Groundwater exceeding cleanup levels would also be collected from seeps downgradient of Honeymoon Heights. A second groundwater barrier, collection, and conveyance facility would be constructed on the north, east, and west sides of Tailings Piles 2 and 3 during the second phase of remedial construction to address ARD from this area. Intercepted groundwater would be conveyed through a combination of pipelines and open ditches to be treated before it is discharged into Railroad Creek (Figure 18). The water would be conveyed primarily by gravity flow, but depending on the final location of the treatment facility, pumping may also be required for at least some of the intercepted groundwater. The final alignment of the barrier wall and the southerly extent (e.g., between Tailings Piles 1 and 2, and on the east side of Tailings Pile 3) would be determined during remedial design, as discussed in the ASFS.

Hydraulic bulkheads would be installed in the mine to control the rate of groundwater discharging from the Main Portal. Concentrations of hazardous substances in the Main Portal discharge would be reduced by installing air restrictors in open portals to reduce airflow through the mine, thus reducing the rate of oxidation of sulfide minerals within the mine. The Main Portal discharge would be conveyed by pipeline to the groundwater treatment system, to prevent AMD discharge to Railroad Creek.

Three alternative locations for the treatment facility were evaluated in the FS. As discussed in the ASFS, final location and configuration of the treatment facility will be determined during remedial design considering both performance

requirements and environmental tradeoffs. The location evaluated for Alternative 11M (north of Railroad Creek and east of Tailings Pile 3) has the advantage that it could be constructed without destruction of the wetland east of the tailings piles, but would require pumping the most groundwater for treatment. The location east of Tailings Pile 3 that was evaluated as part of Alternatives 13M and 14 would not require groundwater to be pumped, but would destroy the wetland. Finally, the location in the Lower West Area that was considered as part of Alternatives 13M and 14 would occupy a portion of the Railroad Creek floodplain that might otherwise be restored as riparian habitat following cleanup of the Lagoon Area and the Lower West Area.

These three alternatives include treatment of the collected groundwater by acid neutralization and precipitation, which will produce a by-product sludge that must be disposed of. Under Alternatives 11M and 14, the water treatment system sludge would be disposed of in a lined on-site landfill designed and constructed for this purpose. The potential use of an unlined sludge disposal facility, possibly on Tailings Pile 1 (i.e., within a groundwater containment area) could be further evaluated during remedial design, as proposed by Intalco for Alternative 13M.

Surface Water

Stormwater diversion swales would be constructed upgradient from Tailings Piles 1, 2, and 3 and the East and West Waste Rock Piles to control surface water run-on.

Surface water impacts to Railroad Creek from groundwater are addressed in this alternative by:

1) Relocating a portion of Railroad Creek as described above;

2) Installing groundwater barriers on the north, east, and west sides the Lower West Area and Tailings Pile 1, and the north, east, and west sides of Tailings Piles 2 and 3 to stop the discharge of contaminated groundwater as base flow into the creek;

3) Collecting and treating groundwater seeps and discharge from the mine; and

4) Preventing instability of the tailings piles that could cause the physical transport of tailings into the creeks.

The new creek channel will be lined where needed to prevent infiltration of clean water from the creek into the groundwater collection system, to minimize the volume of water that needs to be treated.

Former Mill Building

Unsafe structural components would be demolished as needed to investigate and, as needed, remove contaminated soil and ore processing residuals. Soil exceeding cleanup levels at the former Mill Building would be capped in place or excavated and consolidated with the tailings piles prior to capping, or disposed of off site, depending on results of waste designation during remedial design or implementation of the remedy.

9.1.5 Remedy Components Common to Alternatives 11M, 13M, and 14

Alternatives 11M, 13M, and 14 have a number of remedy components that are the same or likely to be so similar that they would not significantly change the comparison of the three alternatives. These remedy components are discussed in more detail in the ASFS and the Proposed Plan.

Some remedy components, while the same or very similar between the alternatives, warrant discussion. These components address work that limits future human exposure to hazardous substances at the Site, support construction work on remedy implementation, and monitor long-term effectiveness of the remedy. These components include institutional controls, remedy support infrastructure, and monitoring.

Institutional Controls

Administrative measures would be implemented to help protect the effectiveness of the remedy from changes in land use and reduce human exposure to remaining Site risks. These institutional controls would be required for hundreds of years.[19]

---

[19] Oxidation of sulfide minerals in the tailings and waste rock would gradually reduce the release of hazardous substances through source depletion. Appendix E of the DFFS provided an estimate for the duration that the tailings piles would continue to release hazardous substances to groundwater "for at least several decades" after the cessation

Institutional controls would be applied to all areas of the Site where hazardous substances are left in place, and, if not controlled, would present a risk to human health and the environment. These areas include the tailings and waste rock piles, Honeymoon Heights, the Lower West Area, Holden Village, the Wind-Blown Tailings Area, and possibly other areas such as the Ballfield Area depending on decisions that are made during remedial design or implementation of the remedy. These institutional controls would:

- Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;
- Protect the integrity of the remedy by preventing changes in Site use that would reduce effectiveness of the remedy;
- Include a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective;
- Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;
- Prevent the potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;
- Provide for permanent access to privately-owned land in order to monitor and maintain the remedy; and
- Implement possible administrative access restrictions to some portions of the Site.

The Forest Service would be responsible for implementing, monitoring, and enforcing the institutional controls on National Forest System lands, through the

---

of iron (and other metals) being generated by oxidation of sulfide minerals, but did not provide any estimate of when this ongoing chemical reaction might end. The DFFS analysis predicted that concentrations of metals in the mine drainage may decrease on the order of 50 percent over the next 60 years, but these concentrations would still significantly exceed cleanup levels and the mine would remain a source of ARD for an unknown period that may also be on the order of hundreds of years.

notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest. Institutional controls will be implemented on private property owned by Holden Village (the patented mining claims) through a restrictive covenant.

Remedy Support Infrastructure

Remedy support infrastructure would include quarry site(s), borrow pit(s), reconstruction of the Lucerne barge landing facility, construction of a work camp and/or related infrastructure improvements at Holden Village, improvements to the Lucerne-Holden Road and bridges, electric power infrastructure, and other infrastructure, as needed. Development of hydroelectric power generating capacity as part of the remedy is highly desirable.

Long-Term Monitoring

Implementation of the remedy includes long-term monitoring to assess remedy performance, ARAR compliance, and protectiveness. Monitoring would be accomplished in accordance with a plan approved by the Agencies. Additional monitoring would also be required to determine whether additional remedial action is warranted, as summarized below:

- Monitoring seep SP-26, as well as groundwater downslope of Honeymoon Heights, to determine whether additional groundwater should be collected for treatment following implementation of source controls.

- Long-term sediment monitoring in Railroad Creek and in Lake Chelan at the Lucerne Bar to confirm that risks are low and decrease over time following implementation of source controls.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section discusses the Agencies' evaluation of Alternatives 11M, 12, 13M, and 14 under CERCLA and MTCA.

10.1 Evaluation of Alternatives under CERCLA

Under CERCLA, the following criteria are used to evaluate remedial alternatives:

Threshold Criteria

1) Overall protection of human health and the environment.

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

2) Compliance with ARARs.

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), and the NCP at 40 C.F.R. § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations which are collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4).

Primary Balancing Criteria

1) Long-term effectiveness and permanence.

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain on the Site following remediation and the adequacy and reliability of controls.

2) Reduction of toxicity, mobility, and volume through treatment.

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of treatment technologies that may be included in the remedy.

3) Short-term effectiveness.

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

4) Implementability.

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

5) Cost.

Cost of each alternative includes the capital cost and the net present worth of long-term costs to operate, maintain, and monitor the remedy.

Modifying Criteria

1) State acceptance of the alternatives.

This criterion considers acceptability of the alternative to the state where the site is located including the degree to which the alternative satisfies state requirements.

2) Community acceptance of the alternatives.

This criterion considers the degree to which the alternative is acceptable to the public, based on comments received on the Proposed Plan.

The threshold criteria are requirements that an alternative must meet to be eligible for selection. The primary balancing criteria form the basis for evaluation of alternatives that satisfy the threshold requirements. The modifying criteria are evaluated in the ROD following receipt of state and public comments on the RI/FS and the Proposed Plan.

10.1.1 Threshold Criteria

The threshold criteria are: 1) overall protection of human health and the environment; and 2) compliance with ARARs.

Overall Protection of Human Health and the Environment

Alternatives 11M, 13M, and 14 would each protect human health.

- Under Alternative 14, risks to humans from soil (including the tailings and waste rock in Tailings Piles 1, 2, and 3, and the East and West Waste Rock Piles), at the former Mill Building, Lagoon Area, Maintenance Yard, a portion of the Lower West Area, and the Ventilator Portal Surface Water Retention Area would be addressed by capping the material in place or moving the material and then capping it to prevent exposure. Risks from soil materials in the remainder of the Lower West Area, Honeymoon Heights Waste Rock Piles, and DSHH would be addressed through institutional controls.

- Alternative 13M addresses human-health risk from impacted soil (including soil with hazardous substances that exceed human health-based criteria for protection of groundwater) through a combination of removal, capping, and institutional controls. However, in the Lower West Area, Honeymoon Heights Waste Rock Piles, and DSHH AOIs, where there is risk to humans from direct contact or ingestion of hazardous substances in soil, Alternative 13M would rely solely on institutional controls and would not include any active cleanup measures.

- Alternative 11M would protect human health in the same manner as Alternative 14, except that Alternative 11M would address exposure to waste rock at Honeymoon Heights and soil in the DSHH that exceed direct contact and ingestion-based cleanup levels by moving the waste rock and impacted soil to the tailings piles for capping, while Alternative 14 would rely on *in situ* treatment and institutional controls.

Potential future use of impacted groundwater and surface water for drinking would be restricted by institutional controls for these three alternatives, and by containing water above drinking water standards in designated WMAs under Alternatives 11M and 14. In addition, safety to residents and visitors would be addressed through mine access restrictions.

Under Alternative 14, risks to terrestrial organisms from Tailings Piles 1, 2, and 3, the East and West Waste Rock Piles, former Mill Building, Lagoon Area, Maintenance Yard, a portion of the Lower West Area, and the Ventilator Portal Surface Water Retention Area would be addressed by excavation (consolidation) or capping hazardous substance containing materials in place to prevent exposure. Risks to terrestrial receptors in other areas (e.g., the remainder of the Lower West Area, Wind-Blown Tailings Area (except excavation incidental to other parts of the remedy), the remainder of the Ballfield Area, and in Holden Village) would be addressed by *in situ* treatment.

To protect aquatic organisms, contaminants from groundwater (including base flow, seeps, and the mine drainage) would be intercepted and treated before it discharges to surface water. The potential release of hazardous substances into Railroad and Copper Creeks from failure of the tailings pile slopes would be addressed by regrading, buttressing, and capping, and by stabilizing the existing and relocated reaches of Railroad Creek. Risks to aquatic organisms from ferricrete would be addressed by rerouting Railroad Creek. The toe of the tailings piles adjacent to Copper Creek (and possibly some areas along Railroad Creek, depending on the extent of creek relocation) would be pulled back as needed to construct stable slopes and the groundwater containment and collection components. Relocation of the creek (or moving the toe of the tailings piles away from the creek) is also needed to protect the tailings piles from erosion and scour by Railroad and Copper Creeks. Sediment in Railroad Creek and Lake Chelan would be monitored to confirm that risks are low and decrease over time following implementation of source controls.

Alternative 11M would protect the terrestrial and aquatic environment in a manner similar to Alternative 14, with a few significant differences:

- Under Alternative 11M, protection of the Railroad and Copper Creeks from tailings piles instability would require pulling the toe of the tailings piles back along the slopes abutting the creeks; and

- Under Alternative 11M, exposure to waste rock at Honeymoon Heights and DSHH would be addressed by moving the material to the tailings piles and capping it rather than through *in situ* treatment.

Alternative 11M would protect the aquatic environment in a manner similar to Alternative 14. Both these alternatives include regrading to stabilize the tailings pile slopes adjacent to the creek and capping, as well as a groundwater barrier and collection system between the tailings piles and the creeks.

Alternatives 11M and 14 differ in the location of the proposed treatment facility needed to protect surface water. Alternative 11M would enable the wetland east of Tailings Pile 3 to be remediated, whereas, under Alternative 14 the wetland would become the location of the treatment facility.

There are significant differences in the way in which Alternative 13M would address the environment compared to Alternatives 14 and 11M. Because of these differences, (which are more fully discussed in Sections 6.2.2 and 6.3.2 of the ASFS), Alternative 13M would not fully protect the environment.

- Under Alternative 13M, the risk to terrestrial receptors from materials in the Lower West Area, Honeymoon Heights Waste Rock Piles, DSHH, and Holden Village would not be addressed, except by monitoring.

- Alternative 13M would intercept and treat impacted groundwater from some parts of the Site before it enters surface water, and includes the former Railroad Creek channel as the collection system along the northwest side of Tailings Pile 2, but it does not include a barrier wall or other active remedial measures downgradient of Tailings Piles 2 and 3. Groundwater impacted by releases from Tailings Piles 2 and 3 exceeds aquatic life protection criteria and contributes to the extensive adverse impacts to surface water quality and aquatic life adjacent to and downgradient of the tailings piles. There is no evidence that Alternative 13M would meet proposed surface water cleanup levels in groundwater before surface water enters Railroad Creek downstream from Tailings Piles 2 and 3.

Similar to Alternative 14, Alternative 13M would involve construction of a groundwater treatment facility within the wetland east of Tailings Pile 3.

Alternative 12, the No Action Alternative, would not protect human health or the environment, since it would not address risks from the ongoing release and presence of hazardous substances at the Site.

Compliance with ARARs

The other threshold criterion under CERCLA is compliance with ARARs [42 U.S.C. § 9621(d)(2); 40 C.F.R. § 300.430(e)(9)(iii)(B) & (f)(1)(i)(A)]. In this section, the alternatives are assessed to determine ARARs attainment under federal environmental laws and state environmental or facility siting laws, or whether there are grounds for invoking one of the waivers listed in 42 U.S.C. § 9621(d)(4); 40 C.F.R. § 300.430(f)(1)(ii)(C).

The ability of the alternatives to meet chemical-specific ARARs at the points of compliance (POCs) for surface water, groundwater, and soil, and to meet action-specific ARARs are compared below and in Tables 16 (chemical-specific ARARs) and 17 (action-specific ARARs). Tables 18 and 19 also summarize the location-specific ARARs and TBCs that would be satisfied by these alternatives. See Table 20 for a description of POCs.

Chemical-Specific Requirements for Surface Water

Under Alternatives 11M and 14, implementation of cleanup actions is expected to satisfy chemical-specific ARARs for surface water based on protection of aquatic life in Railroad Creek and the Copper Creek Diversion.

Alternatives 11M and 14 both address all identified, existing sources of hazardous substance releases into surface waters through containment, collection, and treatment. Thus, these alternatives are expected to satisfy potential chemical-specific ARARs for surface water including the National Recommended Water Quality Criteria (NWQC), National Toxics Rule, Maximum Contaminant Levels (MCLs), Washington State Drinking Water Standards, Washington State Water Quality Standards for Surface Water, and MTCA.

Alternative 11M includes design and operation of the treatment plant to meet discharge limits, which could include a mixing zone, if approved. Alternative 14 includes design and operation of two groundwater treatment plants that may be operated in series or independently, to treat flows from different portions of the Site to meet discharge limits, which could include a mixing zone, if approved.

It is unlikely that Alternative 13M would satisfy chemical-specific ARARs for surface water, such as the NWQC, Washington State Water Quality Standards for Surface Water, and MTCA. Alternative 13M addresses many—but not all—identified, existing sources of hazardous substance releases into surface waters through containment, collection, and treatment. Under Alternative 13M, uncontrolled discharge of groundwater, containing hazardous substances in concentrations greater than water quality criteria, would continue into surface water from Tailings Piles 2 and 3. There is no evidence that the other actions contemplated in Alternative 13 will reduce those concentrations to levels that meet water quality standards. The uncontrolled discharge creates considerable uncertainty as to whether Alternative 13 can meet surface water cleanup levels based on protection of aquatic life in Railroad Creek downstream from Tailings Piles 2 and 3.

Drinking water ARARs for surface water would be met for these three alternatives.

Chemical-Specific Requirements for Groundwater

Under Alternatives 11M and 14, the groundwater barrier walls will provide containment so that the areas within the walls qualify for designation as a WMA.

Without these WMAs, MCLs would need to be met throughout the Site. Under Alternatives 11M and 14, groundwater exceeding MCLs would be contained within WMAs. Following implementation, Alternatives 11M and 14 are both expected to meet chemical-specific ARARs for groundwater in areas at and beyond the edge of the WMAs.

Intalco's description of Alternative 13M did not include containment and, therefore, would not include designation of establishing any WMAs. It is unlikely that Alternative 13M would meet MCLs in groundwater under and downgradient of Tailings Piles 2 and 3. Because of this lack of containment, Alternative 13M also cannot satisfy the requirements for establishing a conditional point of compliance under WAC 173-340-720(8)(c) & (d) as related to achieving groundwater cleanup levels for surface water protection. These requirements include that a conditional POC "be as close as practicable to the source of hazardous substances" provided that all practicable methods of treatment are used in the Site cleanup [WAC 173-340-720(8)(c)], and that before a conditional POC may be established at the point(s) where groundwater enters surface water, AKART must be applied, among other conditions [WAC 173-340-720(8)(d)(i)]. Under CERCLA, cleanup levels based on protection of surface water must similarly be met before groundwater enters Railroad Creek downgradient of Tailings Piles 2 and 3.

Chemical-Specific Requirements for Soil

Under Alternatives 14 and 11M, soil exceeding cleanup levels would be addressed through a combination of removal, containment, *in situ* soil treatment, and monitoring. Alternatives 11M and 14 are both expected to meet chemical-specific ARARs for soil established under MTCA.

Except for monitoring, Alternative 13M does not address soil contamination in the following areas: Honeymoon Heights Waste Rock Piles, the DSHH, Lower West Area (outside the Lagoon Area), or Holden Village. Alternative 13M assumes that remediation would occur naturally over time. As a result, Alternative 13M would not satisfy chemical-specific ARARs for soil.

Action- and Location-Specific Requirements

The Agencies anticipate that Alternatives 11M and 14 would satisfy potential action-specific ARARs. It is not clear whether Alternative 13M satisfies all action-specific ARARs. Additional information would need to be developed during

remedial design/remedial action to determine whether Alternative 13M would satisfy potential action-specific ARARs, including:

- Intalco has not presented information that shows that the 6-inch soil/gravel and wood slash cover proposed for the tailings and waste rock piles (or the 12-inch cover discussed in URS 2010a) would satisfy the performance requirements for closure of limited purpose landfills [WAC 173-350-400(3)(e)(i)] which is the primary ARAR for capping the tailings and waste rock piles at the Site.

- Intalco has not presented information to support its proposal to construct unlined ponds as part of the groundwater treatment system. Use of unlined ponds would not satisfy ARARs including Chapter 90.48 RCW, Chapter 90.54 RCW, WAC 173-240-130(2)(t), and WAC 173-201A because the lining is required to prevent seepage from the ponds that would violate state water quality standards.

Mitigation to address adverse impacts of the cleanup action, e.g., destruction of habitat to construct remedy components, disturbance of habitat (especially for threatened and endangered species) during construction; visual quality; air quality; etc., would be implemented as required by the Forest Plan.[20] If mitigation would not satisfactorily address Forest Plan requirements, the Forest Service may amend the Forest Plan or portions of this ARAR could be waived under CERCLA, if appropriate.

Monitoring during and after implementation would be used for these three alternatives, to assess compliance, as required under both CERCLA and MTCA action- and location-specific ARARs.

Washington's Sediment Management Standards are relevant and appropriate, including provisions that prohibit activities that would degrade existing beneficial uses [WAC 173-204-120], and specify procedures for managing sources of

[20] The Forest Plan refers to the Land and Resource Management Plan for Wenatchee National Forest (LRMP, Forest Service 1990), as amended by Pacific Northwest Forest Plan (NWFP, 1994) and subsequent amendments of the NWFP (2001, 2004, and 2007). The Forest Plan is required under the National Forest Management Act [16 U.S.C. §§ 1600 – 1614] (NFMA) which is the primary statute governing the administration of National Forests.

sediment contamination [WAC 173-204-400]. Under Alternatives 14 and 13M, the adverse effects of ferricrete on aquatic habitat in Railroad Creek would be eliminated by stream relocation. Ferricrete would be removed from Railroad Creek under Alternative 11M.

Remediation under Alternative 11M and 14 would include preventing the discharge of iron- and aluminum-rich groundwater from the tailings piles, which would prevent formation of floc that contains hazardous substances in Railroad Creek. Under both Alternative 11M and 14, sediment in Railroad Creek downstream from Tailings Pile 3 and sediment in Lake Chelan at the Lucerne Bar would be monitored to confirm that risks to benthic macroinvertebrates are low and decrease over time through natural deposition of clean sediment.

Under Alternative 13M, groundwater containing elevated concentrations of dissolved iron and aluminum would continue to flow into Railroad Creek from Tailings Piles 2 and 3. As a result, floc containing hazardous substances would continue to form in Railroad Creek and affect aquatic receptors.

10.1.2 Primary Balancing Criteria

According to the NCP, the selected alternative must provide the best balance of tradeoffs among alternatives (that satisfy the threshold criteria) in terms of the five primary balancing criteria [40 C.F.R. § 300.430(f)(1)(ii)(E)].

Under CERCLA, only alternatives that meet the CERCLA threshold criteria for selecting a final remedy are typically carried forward and compared using the primary balancing criteria. As mentioned in Section 9, Alternatives 1 through 10 that are summarized in Table 14, did not meet the threshold criteria and were not carried forward in the comparative analysis. Alternatives 14 and 11M meet the threshold criteria and, therefore, were carried forward. Although Alternative 13M does not meet the threshold criteria, it is also carried forward in the following discussion for completeness and to better compare and understand these three alternatives.

Long-Term Effectiveness and Permanence

Alternatives shall be assessed for their long-term effectiveness and permanence, along with the degree of certainty that the alternative will be successful [40 C.F.R. § 300.430(e)(9)(iii)(C)]. The two factors considered for long-term effectiveness and permanence are:

- Magnitude of residual risk remaining from the untreated waste or treatment residuals remaining at the conclusion of the remedial activities; and

- Adequacy and reliability of controls necessary to manage treatment residuals and untreated waste.

Magnitude of Residual Risk Remaining at the Conclusion of the Remedial Activities

Alternatives 11M and 14 would fully address human health and ecological risk associated with soil (including tailings and waste rock) in most areas of the Site, as well as all groundwater, surface water, and sediment. Pending the result of treatability studies during remedial design, there is some question of the time required for *in situ* treatment to achieve cleanup levels, and whether the *in situ* treatment proposed for Alternatives 11M and 14 would fully address risks to terrestrial receptors in Holden Village, portions of the Ballfield Area, and portions of the Lower West Area. Alternative 11M includes removal of waste rock and impacted soil from the Honeymoon Heights Waste Rock Piles and the DSHH Area, whereas Alternative 14 would use *in situ* treatment in these areas to avoid the adverse environmental impacts caused by construction of an access road and long-term erosion of steep slopes in this area. Site-specific studies during remedial design would determine the most effective methods of treatment and whether pH adjustment could, in fact, be accomplished without causing other more adverse impacts than the existing risks caused by hazardous substances.

Alternative 13M would also address human health-based risks associated with soil. Alternative 13M would rely on what Intalco refers to as "natural recovery" but does not include any active measures to address risks to terrestrial organisms in the Lower West Area, Honeymoon Heights, Holden Village, DSHH, and the Ballfield Area. Alternative 13M would not address potential risks to aquatic organisms associated with groundwater from Tailings Piles 2 and 3 discharging to Railroad Creek.

Alternative 13M would result in more residual risk at the conclusion of remedial activities compared to Alternatives 11M and 14.

Adequacy and Reliability of Controls

To assess the adequacy and reliability of controls at the Site, items to be addressed under CERCLA are: 1) uncertainties associated with land disposal of treatment system residuals; 2) potential need to replace technical components of

the remedy; and 3) potential risk if components of the remedy need replacement [40 C.F.R. § 300.430(e)(9)(iii)(C)(2)]. These three items are discussed below.

Alternatives 11M, 13M, and 14 each include permanent disposal of water treatment system sludge in a monitored on-site landfill constructed for that purpose. Since the landfill would need to satisfy state requirements for location, design, construction, operation, closure, and monitoring of limited purpose landfills, it is unlikely that hazardous substances would be re-released to the environment from the landfill for any of these three alternatives.

Technical component replacement requirements under Alternatives 11M, 13M, and 14 would be similar, except that the membrane liner system used in the Alternative 11M tailings and waste rock pile caps would be more difficult to maintain and repair compared to Alternatives 13M and 14.

As discussed in the ASFS, there would be a similarly low risk to human health and the environment, compared with existing conditions, should remedy components fail or need to be replaced under Alternatives 11M, 13M, and 14.

Reduction of Toxicity, Mobility, or Volume through Treatment

The second criterion of the primary balancing criteria is assessing the degree to which alternatives employ treatment to reduce toxicity, mobility, or volume, including how treatment is used to address the principal threats posed by the Site [40 C.F.R. § 300.430(e)(9)(iii)(D)].

Under Alternatives 11M, 13M, and 14 hazardous substances would be immobilized in sludge contained in an on-site landfill following treatment of intercepted groundwater. Alternatives 11M and 14 would prevent migration of hazardous substances in groundwater from the known source areas. Alternative 13M would not prevent migration of hazardous substances in groundwater under Tailings Piles 2 and 3, and contaminated groundwater would continue to discharge to Railroad Creek.

Short-Term Effectiveness

Evaluation of short-term effectiveness under CERCLA includes the following items:

- Short-term risks that might be posed to the community during implementation of an alternative;

- Potential impacts on workers and the effectiveness and reliability of protective measures;

- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigation measures during implementation; and

- Time until protection is achieved.

Short-term risks to the community would be primarily associated with construction traffic and would be similar under Alternatives 11M, 13M, and 14. The risk would be mitigated through implementation of a traffic control plan.

Potential impacts to workers during remedial construction would be similar for Alternatives 11M, 13M, and 14 and would generally include construction hazards: mine entry, traffic, exposure to site soil, excavation, demolition, and heavy equipment operation. These could be adequately mitigated under each alternative through adherence to applicable safety and health regulations (OSHA, L&I, MSHA, etc.) including worker training, monitoring, and protective measures.

Human health risks associated with remedy implementation also include handling fuel and caustic chemicals used in operating the groundwater treatment system. For these three alternatives, this risk can be mitigated through development and implementation of an appropriate accident prevention plan and worker training.

These three alternatives have some **potential adverse environmental impacts** that are not compliant with the Forest Plan. Mitigation to address adverse impacts such as permanent habitat destruction, temporary disturbance of habitat during construction, visual impacts, etc., would be implemented as required by the Forest Plan. In the event mitigation would not satisfactorily address requirements of the Forest Plan, the Forest Service may amend the Forest Plan or portions of this ARAR could be waived under CERCLA.

The relative effects of Alternatives 11M, 13M, and 14 are discussed in the ASFS and summarized below.

- Alternatives 11M, 13M and 14 each involve construction of hydraulic barriers in the underground mine and share a common risk that this will degrade water quality of the mine discharge. However, each of these alternatives includes collection and treatment of the mine discharge.

- Alternative 11M would almost immediately prevent the discharge of groundwater into surface water with concentrations above aquatic life protection levels. The time for groundwater between the barrier wall and Railroad Creek to achieve cleanup levels has not been determined, but is expected to be on the order of months or a few years at most, since the groundwater barrier wall would be located immediately adjacent to the creek. Alternative 14 would delay construction of the second phase groundwater barrier and collection system for 5 years, which would decrease its short-term effectiveness relative to Alternative 11M. In contrast, Alternative 13M would not contain groundwater impacted by releases from Tailings Piles 2 and 3, and the Agencies expect the adverse impacts to Railroad Creek would continue for tens if not hundreds of years.

- Alternatives 11M, 13M, and 14 would each mitigate future physical impacts to Railroad Creek by substantially reducing the risk of tailings pile instability. Alternatives 14 and 11M include pulling back portions of Tailings Piles 1 and 2 from Copper Creek and improvements to the Copper Creek channel. Alternative 13M would not sufficiently reduce the current risk that instability of Tailings Piles 1 and 2 could cause a release of tailings into Copper Creek.

- These three alternatives pose some risk of a bentonite/cement release to surface water during barrier wall construction, with the risk for Alternatives 11M and 14 greater than those for Alternative 13M. These three alternatives also involve the risk of spills of hazardous materials during construction vehicle fueling and maintenance, and from long-term operation of the treatment system.

- Alternative 14 includes *in situ* treatment to address the Honeymoon Heights Waste Rock Piles, the DSHH, a portion of the Ballfield Area, Holden Village, and a portion of the Lower West Area. Depending on the effectiveness of *in situ* treatment, this could increase the time required before cleanup levels are achieved in these areas, but with significantly less disturbance and loss of habitat compared to more intrusive measures contemplated by Alternative 11M. If *in situ* treatment is not effective, Ecology, under MTCA, could use its substantive authority under SEPA to not require other active measures with greater potential adverse impacts on the existing habitat. For the purposes

of CERCLA, a waiver of the MTCA ARAR relating to cleanup standards may be appropriate based on 42 U.S.C. § 9621(d)(4)(B), which allows an ARAR to be waived where the harm to the environment is greater because of the implementation of the remedial action than from the contamination itself. Alternative 11M also includes *in situ* treatment for some AOIs, but not Honeymoon Heights. Alternative 11M would have a permanent, adverse impact (e.g., loss of topsoil, long-term erosion and sediment transport downslope, and slope instability) to habitat over an area of 78 acres or more following removal of waste rock and contaminated soil from Honeymoon Heights. These impacts include: 1) destruction of habitat associated with road construction and removal of the impacted soils and waste rock piles; and 2), long-term habitat damage associated with converting forested habitats to bedrock, and erosion, sedimentation, and mass wasting processes from disturbance of the steep-sloped Honeymoon Heights. Alternative 13M does not accomplish any cleanup to reduce risk to terrestrial receptors from soil in the Honeymoon Heights Waste Rock Piles, the DSHH, Lower West Area, Holden Village, and the Wind-Blown Tailings Area.

- Alternative 11M would have a greater risk of surface water quality exceedances associated with discharge from the groundwater treatment facility compared to Alternatives 13M and 14. Although these three alternatives would use similar pH adjustment and precipitation methods to remove hazardous substances during treatment, Alternative 11M relies on pumping, whereas Alternatives 13M and 14 are proposed to be gravity flow-through systems. Alternative 11M could produce surface water quality exceedances if there is a pump or generator failure during the life of the remedy. Alternative 11M could also have higher fuel consumption requirements and, hence, greater risk of a fuel spill compared to Alternatives 13M and 14.

- Alternatives 13M and 14 involve permanent destruction of the wetland habitat east of Tailings Pile 3 for construction of a groundwater treatment facility; whereas, the Alternative 11M treatment system would occupy a portion of the Wind-Blown Tailings Area that is forested. Wetland habitat in the Railroad Creek valley is much less common than forest habitat, so Alternatives 13M and 14 would have greater negative impacts compared to Alternative 11M, in this regard.

The three alternatives also differ in the **time required until protection is achieved**. Time to achieve cleanup levels through *in situ* treatment under Alternatives 11M and 14 will not be known until completion of treatability

studies as part of implementing the remedy, but it is expected to take longer than in the areas where soil is removed and/or capped. Alternative 13M would not be fully protective of the environment since it does not include any active measures to protect terrestrial receptors in the Honeymoon Heights Waste Rock Piles, DSHH, Lower West Area, and Holden Village. Alternative 13M does not contain and treat releases of contaminated groundwater from Tailings Piles 2 and 3 and does not provide data which would indicate the time required until protection of aquatic receptors and surface water ARARs are achieved.

These three alternatives would protect human health at the time the remedy is implemented. However, the three alternatives each have both advantages and disadvantages with respect to short-term effectiveness in protecting the environment. On balance, considering the points listed above, the Agencies concluded that Alternative 14 has overall better short-term effectiveness compared to Alternatives 11M and 13M.

Implementability

Implementability is evaluated under CERCLA considering technical feasibility, administrative feasibility, and availability of services and materials. These three alternatives are considered to be implementable as discussed in the final Feasibility Study (see Section 6.4.2.4 of the ASFS).

Alternatives 14, 11M, and 13M are each technically feasible and could be implemented using conventional construction equipment and methods. Intalco has questioned feasibility of constructing groundwater containment barriers to depths of 100 feet or more (e.g., adjacent to Tailings Pile 3). However, the case history data summarized in Appendix C of the SFS showed this technology has been implemented to depths of more than 100 feet, including in soils with boulders as anticipated at Holden. The equipment, materials, and skilled workers needed are available for use at the Site.

These three alternatives are administratively feasible. The Agencies have reviewed the substantive requirements for similar actions and have determined that these can be met. The Agencies do not foresee any administrative barriers to implementation of Alternatives 14, 11M, or 13M.

Cost

Costs for these three alternatives in 2010 dollars (rounded to three significant figures) are summarized below.[21] Table 21, below, presents a comparison of the net present value of future costs for the alternatives.

Table 21 - Net Present Value of Alternatives

	Alternative 11M	Alternative 13M	Alternative 14
Estimated Capital Cost	$88,500,000	$56,400,000	$76,100,000
Net Present Value of Long-Term Operations, Maintenance, and Monitoring[22]	$31,800,000	$23,400,000	$30,700,000
Total Estimated Cost:	$120,000,000	$79,800,000	$107,000,000

Alternative 11M would cost more than Alternative 14, primarily because of the cost associated with using a geomembrane as part of the cap for tailings and waste rock piles, and the cost of removing the Honeymoon Heights Waste Rock Piles and impacted soil in the DSHH. Additional differences in cost are discussed in Appendix A of the ASFS.

[21] The Agencies prepared cost estimates for these three alternatives to provide a consistent basis for comparison; these are presented in Appendix A of the ASFS. The costs presented in this ROD are based on the Agencies' cost estimates. The Agencies' estimates for Alternatives 11M or 13M include many common components but differ in some aspects from those prepared by Intalco for Alternatives 11 and 13M (URS 2009a). The areas of difference are discussed in detail in Appendix A of the ASFS. The Agencies' estimate for Alternative 11M includes *in situ* treatment and consolidation of impacted soil from some areas that were not considered by Intalco; also the Agencies estimated cost for regrading and stabilizing the tailings piles using the approach Intalco presented for Alternative 13M, which is different from the approach Intalco used for Alternative 11. The Agencies also used different assumptions from Intalco's assumptions, primarily regarding costs for construction labor, supervision, construction mobilization and demobilization, and groundwater treatment costs. The Agencies' estimate for Alternative 13M includes differences from Intalco in the areas of construction mobilization and demobilization, tailings pile stabilization, groundwater treatment and waste disposal, as well as operations, maintenance and monitoring.

[22] The net present value for long-term costs was calculated using a discount rate of 7 percent and a period of 50 years.

Alternative 13M would cost less than Alternatives 11M and 14, as discussed in the ASFS. However, Alternative 13M omits remedy components necessary to satisfy the threshold criteria under CERCLA (or MTCA), so its relative cost would be misleading in selecting a remedy. Alternative 13M costs less than Alternatives 11M and 14 because it does not achieve the same degree of protectiveness as Alternatives 11M and 14, and does not meet ARARs. Alternative 13M would represent an interim step toward a final remedy. It does not take into account the costs of the remaining steps to achieve a final remedy.

10.1.3 Modifying Criteria

Two additional criteria, referred to as modifying criteria, are also considered for remedy selection under CERCLA. These are state acceptance and community acceptance. CERCLA uses the modifying criteria, along with the primary balancing criteria, to determine what is the most appropriate among alternatives that are both protective and ARAR-compliant, see 40 C.F.R. § 300.430(f)(1)(ii).

The State of Washington provided input throughout the RI/FS process and concurs with and supports the Selected Remedy described in this ROD. Through Ecology, the state is adopting this ROD as a cleanup action plan (CAP) under MTCA, pursuant to WAC 173-340-380(4).

Members of the public, including Intalco and Holden Village residents commented on the Proposed Plan. More than 900 comments were received and were considered by the Agencies as discussed in Part 3 of this ROD.

The majority of the comments were submitted on behalf of Intalco or on behalf of Holden Village. The Agencies indexed each comment and sorted them into 75 categories so that similar comments could be addressed in a consistent way. There were 10 or fewer comments in most categories, but there were more than 50 comments in a few of the categories.

Many of the comments addressed reasons why the commenter believed Alternative 13M would be a more appropriate basis for the selected remedy than Alternative 14; for example there were 17 comments that addressed how or why the comment writer believed Alternative 13M satisfies the state's requirements for AKART. Alternative 13M does not meet the CERCLA threshold criteria of protecting human health and the environment and meeting ARARs, as discussed in more detail in Section 10.1 of this ROD and in the response to comments (Part 3).

Many comments also addressed the desirability of minimizing adverse impacts of remedy construction on Holden Village's operations. The Agencies divided the remedy into two phases to reduce impacts to Holden Village's operations (see the discussion of Remedy Phasing in Part 1 of this ROD for further details). The Agencies expect to work with Holden Village and Intalco throughout remedy design and implementation to consider and address potential adverse impacts.

Based on the comments received, the Agencies modified the Preferred Alternative slightly to create the Selected Remedy, as discussed in Section 14 of the ROD, in conformance with the NCP [40 C.F.R. § 300.430(f)(4)(i)]. The most important change was reassessment of soil cleanup levels in some areas of interest through consideration of plant and animal tissue data as indicated in Section 7.1 of the ROD, and discussed in more detail in Houkal and Dagel (2011). As a result of this reassessment, the Selected Remedy does not require *in situ* treatment in the Wind-blown Tailings Area, and changes the remedy for the Ballfield Area from *in situ* soil treatment, as presented in the Proposed Plan, to a combination of hot spot investigation/removal along with possible *in situ* treatment.

10.1.4 Summary of Rationale for the Selected Remedy

The Agencies selected a final remedy based on information presented in the Administrative Record and considering public comments on the Proposed Plan as documented in this ROD. As outlined in Sections 10.1.1 and 10.2.1, Alternatives 11M and 14 both satisfy the threshold criteria for selection of a remedy under CERCLA and MTCA, but differ in their ability to satisfy some of the primary balancing criteria. Overall, Alternative 14 provides the best balance of the criteria and is the basis for the Selected Remedy.

The main advantages of Alternative 14 are as follows:

- Alternative 14 avoids long-term, potentially permanent habitat loss near the Honeymoon Heights Waste Rock Piles and the DSHH area, and for construction of the access road to remove waste rock and impacted soil on Honeymoon Heights. Alternative 14, therefore, would avoid long-term, possibly permanent, habitat degradation to an estimated 70 acres downslope of the Honeymoon Heights access road and waste rock piles, caused by changes in drainage and instability. Unlike Alternative 11M, Alternative 14 uses *in situ* treatment of soil in these areas, which would not require heavy equipment access or involve significant soil disturbance.

- Alternative 14 involves less risk of tailings releases to surface water during construction than Alternative 11M. Unlike Alternative 11M, Alternative 14 does not involve as much regrading and excavation immediately adjacent to Railroad Creek to relocate the toe of the tailings piles.

- Alternative 14 involves less risk of sedimentation or bentonite/cement release to surface water during construction because barrier walls would not be constructed immediately adjacent to Railroad Creek as they would under Alternative 11M.

- The soil caps used on the tailings piles and East and West Waste Rock Piles would be easier to maintain and repair than the membrane liner system used in Alternative 11M.

- Alternative 14 would cost less than Alternative 11M, primarily because it does not involve a geomembrane as part of the cap for tailings and waste rock piles, and removal of the Honeymoon Heights Waste Rock Piles and impacted soil in the DSHH area.

- Alternative 14 would prevent the long-term destruction of habitat over a large area on the steep slopes of Honeymoon Heights and other specified areas of high-value, late successional reserve habitat. As discussed in Sections 1.3, 3.2, and 4.2 of the ASFS, the adverse effects to terrestrial receptors from waste rock and impacted soil above cleanup levels on Honeymoon Heights extends over an area of about 8 acres, compared to an area of about 78 acres (roughly ten times larger) that would be permanently impacted by disturbance and long-term erosion on steep slopes to remove or cap these areas. Similarly, the advantage of removing the waste rock and soil to limit human exposure to hazardous substances would be outweighed by the accompanying long-term destruction of terrestrial habitat, especially in light of the expected effectiveness of institutional controls to control human exposure.

Based on the information currently available, the Agencies believe that the Selected Remedy, based on Alternative 14, meets the threshold criteria and provides the best balance of tradeoffs of the other alternatives with respect to the primary balancing criteria. As described above, the Forest Service and EPA expect the Selected Remedy (based on Alternative 14) to satisfy the following statutory requirements of CERCLA 42 U.S.C. § 9621(b) & (d): 1) be protective of human health and the environment; 2) comply with ARARs except where a waiver is justified; 3) be cost-effective; 4) use permanent solutions and

alternative treatment technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element or justify why the preference is not satisfied.

10.2 Evaluation of Alternatives under MTCA

The State of Washington is concurrently exercising its independent cleanup authority for this Site under MTCA, which is applicable to the Site under state law [RCW 70.105D]. The following discussion is prepared solely for the state's benefit in adopting this ROD as a cleanup action plan under MTCA [see WAC 173-340-380(4)]. It is not a part of the CERCLA decision-making process.

As with CERCLA, the MTCA threshold requirements must be met for an alternative to be considered further. The nine additional requirements (and action-specific), along with the four threshold requirements, used to evaluate alternatives that satisfy the threshold criteria [WAC 173-340-360(2)] include the following:

Threshold Requirements

1) Protect human health and the environment

Similar to CERCLA, the alternative must provide for overall protection of human health and the environment.

2) Comply with cleanup standards

Similar to CERCLA, the alternative must comply with cleanup standards (cleanup levels and the points of compliance where such cleanup levels must be met) as established in WAC 173-340-700 through 173-340-760.

3) Comply with applicable state and federal laws

Similar to CERCLA, the alternative must comply with both applicable and requirements that are determined to be relevant and appropriate, as defined through WAC 173-340-710.

4) Provide for compliance monitoring

Similar to CERCLA, the alternative must provide for compliance monitoring, as established under WAC 173-340-410 and WAC 173-340-720 through 173-340-760.

Other Requirements

1) Use permanent solutions to the maximum extent practicable

The determination of whether an alternative uses permanent solutions to the maximum extent practicable is based on an evaluation of: 1) overall protectiveness of human health and the environment, including consideration of the degree of risk reduction, the time required to reduce risk and attain cleanup levels, on-site and off-site risks resulting from implementing the alternative, and improvement of overall environmental quality resulting from the alternative; 2) permanence, as measured by the degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances; 3) cost, including the cost of construction and the net present value of any long-term costs, such as those associated with operation and maintenance; 4) effectiveness over the long term, including the degree of certainty that the alternative will be successful; 5) management of short-term risks; 6) technical and administrative implementability; and 7) consideration of public concerns. The costs and benefits of each alternative, as defined by the preceding evaluation criteria, are compared in what is referred to as a "disproportionate cost analysis." Only those alternatives meeting threshold requirements are subject to this analysis. Where two or more alternatives are equal in benefits, Ecology is to select the less costly alternative. Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative. This comparison of costs to benefits may be quantitative, but may also be qualitative. Ecology has discretion to favor or disfavor qualitative benefits and utilize its best professional judgment in making such determinations. For complete detail, see WAC 173-340-360(3).

2) Provide a reasonable restoration time frame

The determination of whether an alternative provides for a reasonable restoration time frame is based on an evaluation of: 1) potential risks posed by the site to human health and the environment; 2) practicability of achieving a shorter restoration time frame; 3) current use of the site, surrounding areas, and

associated resources that are or may be affected by releases from the site; 4) potential future use of the site; 5) availability of alternative water supplies; 6) likely effectiveness and reliability of institutional controls; 7) ability to control and monitor migration of hazardous substances from the site; 8) toxicity of the hazardous substances at the site; and 9) natural processes that reduce concentrations of hazardous substances. A longer time period may be used for the restoration time frame if the alternative selected has a greater degree of long-term effectiveness than on-site or off-site disposal, isolation, or containment options. Extending the restoration time frame cannot be used as a substitute for active remedial measures when such actions are practicable. For complete detail, see WAC 173-340-360(4).

3) Consider public concerns

Action-Specific Requirements ("pertaining to" requirements)

1) Groundwater cleanup actions

Where a permanent cleanup action is not practicable (i.e., cleanup levels for groundwater cannot be achieved throughout the Site within a reasonable restoration time frame), then 1) treatment or removal of the source of the release shall be conducted for liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained; and 2) groundwater containment shall be implemented to the maximum extent practicable to avoid lateral and vertical expansion of the groundwater volume affected by the hazardous substance. For complete detail, see WAC 173-340-360(2)(c).

2) Soil at current or potential future residential areas and child care centers

Specific requirements pertaining to soil cleanup at current or potential future residential areas and child care centers are found in WAC 173-340-360(2)(b). These requirements (which relate to soil cleanup levels established for human health protection) are not triggered at the Holden Mine Site.

3) Institutional controls

Institutional controls must comply with the specific requirements of WAC 173-340-440 and should demonstrably reduce risks to ensure a protective remedy. A remedy shall not rely primarily on institutional controls and monitoring where

it is technically possible to implement a more permanent cleanup action for all or part of a site. For complete detail, see WAC 173-340-360(2)(e).

4) Releases and migration

Cleanup actions shall prevent or minimize present and future releases and migration of hazardous substances in the environment. See WAC 173-340-360(2)(f).

5) Dilution and dispersion

Cleanup actions shall not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures over the benefits of dilution and dispersion. See WAC 173-340-360(2)(g).

6) Remediation levels

Remediation levels are defined as the particular concentration of a hazardous substance in any media, above which a particular cleanup action component will be required as part of a cleanup action at the Site. See WAC 173-340-200. Specific requirements pertaining to the use of remediation levels are presented in WAC 173-340-360(2)(h). However, as noted below, remediation levels are not proposed in any of the alternatives analyzed in this ROD.

10.2.1 Threshold Requirements

The threshold requirements for selection of a remedy under MTCA are that a cleanup action:

- Protect human health and the environment;
- Comply with cleanup standards
- Comply with applicable state and federal law; and
- Provide for compliance monitoring.

Protect Human Health and the Environment

For the same reasons that Alternative 14 and Alternative 11M provide for "overall protection of human health and the environment" under CERCLA (see Section 10.1.1.1), Alternative 14 and Alternative 11M satisfy MTCA's requirement that the remedy protect human health and the environment. Alternative 13M would be protective of human health, but would not protect terrestrial receptors in many areas of the Site. The Agencies do not have sufficient information to show that surface water cleanup levels would be met in groundwater that discharges to surface water downstream of Tailings Piles 2 and 3 without a barrier wall. Investigations to date indicate extensive impacts to surface water quality and aquatic life adjacent to and downgradient of the mine from groundwater discharges, including groundwater migrating from Tailings Piles 2 and 3.

Comply with Cleanup Standards

As presented in the ASFS Sections 6.3.1 and 6.3.3, Ecology concludes that Alternatives 11M and 14 would comply with cleanup standards for groundwater, surface water, sediment, and soil. Under Alternative 11M, contaminated groundwater would be contained and treated before entering the surface water. Alternative 14 also includes a groundwater barrier for this purpose that would be constructed in two phases. However, the second phase barrier could be modified or not constructed if certain demonstrations are made by Intalco, as previously described in Section 4.3. Ecology concludes that Alternative 13M does not satisfy cleanup standards under MTCA, as discussed in ASFS Section 6.3.2. Under MTCA, a conditional POC for groundwater may be established where the Site abuts surface water, provided specific criteria are met, [see WAC 173-340-720(8)(d)(i)]. Where groundwater discharges to surface water, the conditional POC under MTCA must be as close as practicable to the source [WAC 173-340-720(8)(c)], but no further within surface water than as close as technically possible to the point or points where groundwater flows into the surface water [WAC 173-340-720(8)(d)(i)]. Among the criteria to be met, MTCA requires that for a cleanup action to qualify for a groundwater conditional POC at the groundwater-surface water interface, groundwater discharges must receive all known available and reasonable methods of treatment (AKART) before release to surface water. As established in the FS, the groundwater barrier walls that are part of Alternatives 11M and 14 satisfy this AKART requirement, and in fact are expected to result in groundwater achieving surface water cleanup levels before entering the portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates, so

as to be protective of aquatic life . The limited groundwater barrier wall configuration under Alternative 13M does not satisfy AKART, because this remedy does not include containment of groundwater underneath Tailings Piles 2 and 3, and there is no evidence that groundwater cleanup levels, based on protection of surface water, would be met before groundwater enters Railroad Creek downstream of Tailings Piles 2 and 3. As a result, Ecology cannot approve a conditional POC under the criteria of WAC 173-340-720(8)(c) and (d) for Alternative 13M. Alternative 13M also does not satisfy cleanup standards under MTCA for soil in several areas of the Site.

Comply with State and Federal Law

For the same reasons that Alternative 14 and Alternative 11M comply with ARARs under CERCLA (see Section 10.1.1), Alternative 14 and Alternative 11M satisfy MTCA's requirement that the remedy comply with applicable state and federal laws. Alternative 13M does not comply with all applicable state and federal laws.

Provide for Compliance Monitoring

Alternatives 11M, 13M, and 14 would each provide for compliance monitoring.

Summary of MTCA Threshold Requirements

As noted in Section 10.1.1, Alternatives 14 and 11M would satisfy the MTCA threshold requirements for selection of a final remedy, but Alternative 13M would not (this is more fully discussed in Sections 6.2.2 and 6.3.2 of the ASFS).

As is the case with CERCLA, alternatives that do not meet the MTCA threshold criteria are not carried forward for further remedy selection comparison (e.g., using the other MTCA requirements). Alternatives 14 and 11M do meet the threshold criteria and, therefore, are carried forward. Although Alternative 13M does not meet the threshold criteria under MTCA, it is also carried forward in the following discussion for completeness and to better compare and understand these three alternatives.

10.2.2 MTCA Other Requirements

Under MTCA, the other requirements for remedy selection require that a cleanup action shall:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration time frame; and
- Consider public concerns.

Alternatives 11M and 14 would both largely satisfy the other requirements for remedy selection under MTCA, but with some differences as summarized below.

Use Permanent Solutions to the Maximum Extent Practicable

Alternative 13M does not address soil exceeding cleanup levels in several areas of the Site and, therefore, cannot be considered permanent for these areas. Alternative 13M also would not prevent groundwater exceeding cleanup levels from entering Railroad Creek downgradient of Tailings Piles 2 and 3. Based on the analysis in Appendix D of the ASFS and Appendix C of the SFS, the Agencies have concluded it is practicable to provide for the containment, collection, and treatment of this groundwater.

- Sections 10.1.2 through 10.1.4 of the ROD provide an extensive discussion of the differences and resulting tradeoffs between Alternatives 14 and 11M. When these differences and tradeoffs are analyzed under the seven evaluation criteria of MTCA's disproportionate cost analysis, Ecology concludes that:

- Alternative 14 is more protective than Alternative 11M;

- Alternative 11M is slightly more permanent than Alternative 14, but at a greater environmental cost;

- Alternative 14 has a lower cost than Alternative 11M;

- Alternative 14 has greater effectiveness over the long term than Alternative 11M;

- Alternative 11M has slightly greater short-term risks than Alternative 14;

- Alternative 11M and Alternative 14 have essentially the same technical and administrative feasibility; and

- The Agencies have the same ability to address public concerns for both Alternative 11M and Alternative 14.

On the whole, Alternative 14 is considered to be more protective and reliable over the long term than Alternative 11M. Alternative 14 requires less operation and maintenance, results in less disturbance to valuable habitat, uses less energy and materials to operate, and is more sustainable, all at a lower overall cost. Alternative 14, therefore, best satisfies the requirement that a remedy be permanent to the maximum extent practicable.

Provide for a Reasonable Restoration Timeframe

Alternative 11M would have a shorter restoration time frame compared to Alternative 14 for cleanup of the Honeymoon Heights Waste Rock Piles and DSHH. However, this would only be achieved by measures more intrusive than *in situ* treatment, and such measures appear likely to cause more adverse impact (permanent habitat loss or damage) than the existing hazardous substance concentrations in these AOIs. Alternative 14 would have a slightly longer restoration time frame compared to Alternative 11M for the area subject to the second phase barrier wall; however, the Agencies believe this is justified based on consideration of the RAOs. The restoration time frame for the remaining AOIs would be the same under both Alternatives 11M and 14. Alternative 13M does not provide a reasonable restoration time frame because it does not address soil exceeding cleanup levels in several areas of the Site and would not prevent groundwater exceeding cleanup levels from entering Railroad Creek downgradient of Tailings Piles 2 and 3.

Public Concerns

Public concerns were addressed in Section 3 of this ROD.

10.2.3 MTCA Action-Specific Requirements

Non-Permanent Groundwater Cleanup Actions

As discussed in the final Feasibility Study, a permanent groundwater cleanup is not practicable throughout the entire Site within a reasonable restoration time frame. Therefore, the selected alternative must meet MTCA's requirements for non-permanent cleanup actions.

Alternatives 11M and 14 include the removal, containment, or *in situ* treatment of the sources of hazardous substances at the Site. These alternatives also include groundwater containment to the maximum extent practicable to avoid lateral and vertical expansion of the groundwater affected by the hazardous

substances. For impacted soil (including tailings and waste rock), consolidation, containment, *in situ* treatment and, possibly, removal are remedy components. As a result, Alternatives 11M and 14 meet the MTCA requirements for a non-permanent groundwater cleanup action.

Alternative 13M includes the removal or containment of some sources of hazardous substances but does not address all soil at the Site that exceeds cleanup levels. Also, Alternative 13M does not include groundwater containment to the maximum extent to avoid expansion of the plume. As a result, Alternative 13M does not satisfy the MTCA requirements for non-permanent groundwater cleanup actions.

Soil Cleanup for Residential and School Areas

As indicated above, these requirements are not triggered at the Holden Mine Site because Holden Village-area soil does not exceed human health standards.

Institutional Controls

Ecology concludes that Alternatives 11M and 14 each satisfies requirements for institutional controls to protect human health that are specified in WAC 173-340-440. However, Alternative 13M relies on more extensive use of institutional controls rather than more permanent cleanup actions to protect human health for a portion of the Site (i.e., in the Ballfield Area and Lower West Area AOIs).

Releases and Migration/Dilution and Dispersion

Ecology concludes that Alternatives 11M and 14 prevent the release and migration of hazardous substances to the maximum extent practicable and do not rely primarily on dilution and dispersion to clean up groundwater and surface water that exceed cleanup levels. However, it appears that Alternative 13M relies on dilution and dispersion east of Tailings Pile 3 to prevent the discharge of groundwater that exceeds cleanup levels to surface water.

Remediation Levels

Alternatives 11M and 14 do not propose the use of remediation levels.

Intalco refers to remediation levels in discussing Alternative 13M, but the Agencies believe Intalco is using this term to refer to site-specific, risk-based cleanup levels, as discussed in the ASFS.

11.0 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practical. A principal threat concept is applied to the characterization of "source material" at a site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act a reservoir for migration of contaminants to groundwater, surface water, or air, or acts as a source for direct exposure. EPA has defined Principal Threat Wastes as those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk (e.g., a potential risk of $10^{-3,}$ or greater) to human health or the environment should exposure occur. EPA guidance also says that contaminated groundwater is generally not considered to be a source material or a principal threat waste. Based on these considerations, there are no Principal Threat Wastes at the Site.

12.0 THE SELECTED REMEDY

12.1 Summary of the Rationale for the Selected Remedy

The Selected Remedy meets the threshold criteria and provides the best balance of tradeoffs of the other alternatives with respect to the primary balancing criteria. In addition to being protective and complying with ARARs, the principal factors that led to this selection include in summary:

- **Long-Term Effectiveness.** The selected remedy avoids long-term, potentially permanent habitat loss near the Honeymoon Heights Waste Rock Piles and the DSHH area, and for construction of the access road to remove waste rock and impacted soil on Honeymoon Heights. Also, the soil caps used on the tailings piles and East and West Waste Rock Piles would be as effective and easier to maintain and repair than other alternatives.

- **Short-Term Effectiveness.** The selected remedy involves less short-term risk of tailings, sediment, or bentonite/cement releases to surface water during construction than other alternatives.

- **Cost.** The selected remedy is the most cost-effective protective alternative.

12.2 Description of the Selected Remedy

This section expands on the description of the Selected Remedy for each area at the Site. The Selected Remedy is based on Alternative 14 with modifications discussed in Section 14 of the ROD. The Selected Remedy may change somewhat during the remedial design and construction processes. Any significant changes to the remedy described in the ROD will be documented using an Explanation of Significant Differences (ESD) or a ROD Amendment.

Table 22, below, summarizes the estimated costs for the Selected Remedy.

Table 22 - Estimated Costs for the Selected Remedy

Selected Remedy	
Estimated Capital Cost	$76,100,000
Net Present Value of Long-Term Operations, Maintenance, and Monitoring	$30,700,000
Total Estimated Cost:[23]	$107,000,000

Figure 18 shows the principal components of the Selected Remedy. Design details for several components of the Selected Remedy will be determined during remedial design. These include final slope grade for the tailings piles and main waste rock piles, design of caps to isolate contaminated materials, final design of the groundwater treatment facilities, Railroad Creek relocation, and *in situ* soil treatment.

12.2.1 Soil

The Selected Remedy includes consolidation of soil that exceeds cleanup levels from most areas of the Site into the tailings piles, and capping the tailings and waste rock piles to isolate these materials from the environment and manage them in place. In some areas, (e.g., the Lagoon, other portions of the Lower West Area, the Maintenance Yard, and the Ballfield Area), further characterization is needed to determine the extent of soil that needs to be

[23] Costs are shown in 2010 dollars, rounded to three significant figures. The net present value of future operations, maintenance and monitoring costs were estimated using a discount rate of 7 percent and period of 50 years. See Appendix A of the ASFS for more information.

removed, capped in place, or treated in place. Capping or soil removal is not proposed in certain critical and sensitive areas or existing topographic conditions where the Agencies believe those actions will cause more ecological harm (e.g., permanent habitat destruction) than the threat posed by existing site contamination. As a result, cleanup in some AOIs includes *in situ* soil treatment to reduce the mobility and bioavailability of hazardous substances. During remedial design, treatability tests will be needed to determine the best approach for *in situ* treatment, including application rates to avoid adverse effects on existing habitat. Results of these tests will provide further detail on the degree and timing of protectiveness that can be achieved with this approach.

AOIs where *in situ* treatment is proposed include: Honeymoon Heights Waste Rock Piles, the DSHH, portions of the Lower West Area, Holden Village, and possibly portions of the Ballfield Area (see Figure 18). Pending completion of *in situ* treatability studies, the effectiveness of this approach is not as certain as removal or capping. Potentially, *in situ* treatment may require more time than an approach with a significant adverse impact, or it may not fully attain cleanup levels. Where *in situ* treatment would not immediately prevent risk to human health (e.g., portions of the Lower West Area and Honeymoon Heights), the Selected Remedy would include signage to warn of human health risks in such areas. CERCLA provides for an ARAR waiver and selection of a remedy that does not attain an ARAR if the administrative record supports a finding that compliance at a given site or portion of a site will result in greater risk to human health and the environment than alternative options. If appropriate, waiver of the cleanup standard in this situation would occur through a ROD Amendment.[24]

Tailings Piles 1, 2, and 3

The following actions will be taken to contain and manage the waste that will remain in Tailings Piles 1, 2, and 3 after the completion of the remedy. The tailings pile slopes will be regraded so they are stable under steady state and

[24] For Ecology's purposes under MTCA, the environmental risk of the cleanup action may be considered as part of a disproportionate cost analysis to determine whether a cleanup action is permanent, to the maximum extent practicable. Washington's State Environmental Policy Act (SEPA) also provides Ecology with substantive authority, subject to certain provisions, to modify a cleanup action to mitigate adverse environmental impacts.

seismic (maximum design earthquake) conditions, are contoured to promote maximum runoff and reduce infiltration, and comply with ARARs. This will include construction of benches for erosion control and, possibly, buttressing. Before regrading, a portion of Railroad Creek will be diverted northward into a new channel, which will also reduce the risk of long-term erosion or scour of the slopes that will release hazardous substances into Railroad Creek. Portions of the toes of Tailings Piles 1 and 2 will be pulled back from Copper Creek and from portions of Railroad Creek as determined necessary by the Agencies.[25] In addition, the Copper Creek channel will be improved to reduce the risk of adversely impacting Tailings Piles 1 and 2.

The three tailings piles will be capped with a cover consisting of soil and/or other materials designed to contain the tailings, reduce exposure to the environment, eliminate unacceptable risk to terrestrial plants and animals and to satisfy ARARs, including the state's performance requirements for closure of limited purpose landfills and Forest Service standards and guidelines. Soil with hazardous substances that are consolidated from other portions of the Site (described below), and possibly excess waste rock from regrading the East and/or West Waste Rock Piles, will be consolidated onto the tailings piles before capping.

East and West Waste Rock Piles

The following actions will be taken to contain and manage the waste that will remain in the East and West Waste Rock Piles after the completion of the remedy. The East and West Waste Rock Pile side slopes will be regraded to configurations that are stable under steady state and seismic conditions and contoured to promote maximum runoff and reduce infiltration. The top and side slopes of the waste rock piles will then be capped with a cover consisting of soil and/or other materials designed to contain the waste rock, reduce exposure to the environment, eliminate unacceptable risk to terrestrial plants and animals, and to satisfy ARARs.

---

[25] This may be needed to provide sufficient room for construction of other remedy components, such as the groundwater containment and collection system, and to address potential risk of erosion and scour. The need for such actions would be determined during remedial design.

Honeymoon Heights Waste Rock Piles (Including DSHH)

The following actions will be taken to contain and manage the waste that will remain in the Honeymoon Heights Waste Rock Piles after the completion of the remedy. The Honeymoon Heights Waste Rock Piles and DSHH AOIs will be cleaned up using *in situ* treatment to reduce bioavailability and mobility of hazardous substances by adjusting pH, to the extent practicable, without degrading existing habitat. The method and rate of application, frequency of treatment, and other aspects will be determined based on treatability tests conducted during remedial design and on post-implementation monitoring. Institutional controls including access warning signs will also be implemented in these areas to address potential human health risks from lead and arsenic.

Ballfield Area

Areas of soil with hazardous substances exceeding cleanup levels will be removed based on the results of further characterization and consolidated into the tailings piles prior to capping. The area will then be revegetated with native vegetation. *In situ* treatment may also be used if further characterization indicates that hazardous substances extend into adjacent areas of late succession riparian habitat.

Holden Village

Soil will be remediated using *in situ* treatment to reduce risk to soil invertebrates resulting from zinc. Institutional controls will be developed and implemented, including a soil management plan to address handling of soil with visible tailings that may be excavated in the future and a requirement for consultation with the Agencies prior to changes in land use to ensure that the remedy remains protective.

Lower West Area, including the Lagoon Area

Impacted soil in some locations (including the Lagoon Area and soil with hazardous substances in existing disturbed areas) will be capped and managed in place or removed and consolidated into the tailings piles prior to capping. The extent of soils to be capped in place or consolidated, and the areas where soils are treated *in situ*, would be determined by additional characterization during remedial design or remedial action. Soil located in areas of late succession riparian habitat (primarily in the Lower West Area-West) will be remediated using *in situ* treatment to limit impacts to this habitat. Institutional

controls (e.g., by restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest including access warning signs) will also be implemented in the Lower West Area to address human health risks from arsenic, cadmium, copper, and lead in soil.

Wind-Blown Tailings Area

A portion of the impacted soil in the Wind-Blown Tailings Area that contains visible tailings will be removed during the work (such as borrow site development, construction of the groundwater treatment facility, and relocation of Railroad Creek) and consolidated into the tailings piles before capping. Additional removal or *in situ* treatment is not included to limit impacts to the high-value, late succession habitat, since reevaluation of the TEE did not indicate terrestrial risks over the entire area. Institutional controls will be implemented to require a soil management plan to address handling of soil with visible tailings that may be excavated in the future, and consultation with the Agencies prior to changes to land use (e.g., if timber harvesting or other ground-disturbing activity occurs) to ensure that the remedy remains protective.

Maintenance Yard

Soil exceeding cleanup levels in the Maintenance Yard area will be capped and managed in place, or the soil will be consolidated into the tailings piles. Holden Village has requested that the remedy allow continued future land use of this area for vehicle maintenance and parking. The extent of the cap or soil removal will be determined based on additional soil characterization during remedial design.

Former Mill Building

The structural components will be demolished as part of managing contaminated soil and ore processing residuals.[26] If State Dangerous Wastes are encountered, they will need to be disposed of off site in a permitted facility. Contaminated materials (not including Dangerous Wastes) may be capped in place or consolidated with other contaminated materials (e.g., tailings and waste rock) on the Site before capping.

[26] See Appendix A for mitigation required under the National Historic Preservation Act.

Ventilator Portal Surface Water Retention Area Soil

Soil above cleanup levels will be capped and managed in place or excavated from the Ventilator Portal Surface Water Retention Area and consolidated into the tailings piles before capping, depending on results of further analysis during remedial design.

Wetland East of Tailings Pile 3

The Selected Remedy would allow, but not require, location of a groundwater treatment system on the north side of Railroad Creek (see Figure 18) that was analyzed as part of Alternative 11M. If the treatment system is not located in wetland east of Tailings Pile 3 as was contemplated for Alternatives 13M and 14, this wetland will be remediated under the Selected Remedy. This shall include removal of visibly contaminated soil, eliminating the adverse effects of runoff and sediment transport from the tailings pile and shallow contaminated groundwater impacted by leaching from the tailings pile. Mitigation will be required to the extent that the wetland is adversely impacted (temporarily or permanently) by remedial construction.

12.2.2 Groundwater

The Main Portal drainage, along with contaminated seeps (SP-12 and SP-23) downslope from Honeymoon Heights, will be collected and treated. Concentrations of hazardous substances in the Main Portal discharge will be reduced by installing air flow restrictors to reduce airflow through the mine, thus reducing the rate of oxidation of sulfide minerals within the mine. Groundwater will be monitored downslope of Honeymoon Heights to determine whether additional groundwater should be collected for treatment.

Water from the Main Portal drainage and seeps SP-12 and SP-23 will be conveyed and treated in a water treatment facility that will be located and constructed based on approved studies during remedial design.

The other main contaminant source areas (e.g., the tailings piles, main East and West Waste Rock Piles, and the Lower West Area) will be managed in place based on the determination in the final Feasibility Study that it would not be practicable to remove these sources of hazardous substances that are impacting groundwater, or to achieve groundwater cleanup levels within these areas within a reasonable restoration timeframe. Management of these wastes in place includes the construction of groundwater containment barrier walls around the

tailings piles, which is necessary to prevent further migration of contaminants in groundwater and to protect downgradient surface water. Groundwater from these source areas will be contained and collected for treatment to prevent migration and discharge to surface water. The tailings and the main waste rock piles will also be capped, and the smaller Honeymoon Heights waste rock piles and impacted soil areas will be treated *in situ*.

The NCP preamble language sets forth the EPA's policy that for groundwater, "remediation levels generally should be attained throughout the contaminant plume, or at and beyond the edge of the waste management area when waste is left in place." The NCP preamble also indicates that in certain situations it may be appropriate to address the contamination as one waste management area for purposes of the groundwater point of compliance; for example this may be protective of public health and the environment at certain sites where there are multiple sources from closely spaced waste management areas. The selected remedy establishes two WMAs, with the Lower West Area including the Tailing Pile 1, the mill, and the East and West Waste Rock Piles as one WMA, and Tailings Piles 2 and 3 as a second. The Selected Remedy includes restoration of groundwater to beneficial uses and associated cleanup levels (MCLs) at and beyond the edge of each WMA. Groundwater points of compliance for meeting MCLs are established at the edge and beyond each WMA. Monitoring for compliance with drinking water standards shall be accomplished outside the WMA, as close as practicable to the edge of the WMA. Institutional controls will be implemented to present use of the groundwater as drinking water within the WMAs.

CERCLA and MTCA both require protection of all affected media and receptors, including those aquatic receptors in the hyporheic zone[27]. Cross-media impacts must be considered and cleanup levels must be established at concentrations that prevent violations of cleanup levels for other media (WAC 173-340-700(6)(b) and 173-340-702(8)). At the Holden Mine Site, this means that cleanup levels established for the protection of aquatic life must be achieved before the portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates, and not simply in the surface

[27] The hyporheic zone is the transition zone between surface water and groundwater. Within this zone, exchanges of water, nutrients, and organic matter occur in response to variations in discharge and stream bed topography and porosity; portions of this zone support aquatic life (see Boulton et al. 1998).

water column after dilution has occurred.[28] Based on this, a POC for groundwater entering into surface water (which is a conditional POC under MTCA) is established within groundwater before (i.e., hydraulically upgradient of) the groundwater–surface water interface.[29] Groundwater quality at this POC shall be monitored using upland monitoring wells.

A fully penetrating groundwater containment barrier wall and collection system will be constructed for the Lower West Area and the tailings piles as generally depicted on Figure 18. The alternatives addressed in the final Feasibility Study contemplated that the groundwater barrier would be constructed using the slurry trench method with a mix of soil and bentonite or soil, cement, and bentonite. The final design of the barrier wall and its southerly extent (e.g., between Tailings Piles 1 and 2, and on the east side of Tailings Pile 3) would be determined during remedial design for the Selected Remedy. During the first phase of remedy implementation, the barrier system will extend from Copper Creek west to where the Main Portal drainage currently discharges into Railroad

---

[28] Based on the analysis in the FS, the containment provided by the groundwater barrier walls in the Selected Remedy will result in groundwater achieving cleanup levels established for the protection of aquatic life within groundwater before the groundwater enters the portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates. A conditional POC at this point is thus "as close as practicable to the source of hazardous substances" under MTCA [WAC173-340-720(8)(c)] and appropriate at the Holden Mine Site, as further described in the text body. WAC 173-340-720(8)(d)(i), which, provided certain criteria are met, allows for a conditional POC that is located within the surface water as close as technically possible to the point or points where groundwater flows into the surface water, is not triggered by the Selected Remedy, since it is practicable to meet the cleanup level at a point within the groundwater before entering the surface water.

[29] The interface is where groundwater first contacts surface water. The depth of the interface is not static (e.g., it may vary from seasonal or other changes in gradient) or uniform in depth across a plume (e.g., based on preferential pathways, areas of upwelling versus downwelling). Taking this into account, the POC for groundwater discharging to surface water at this Site requires compliance monitoring points located within groundwater upgradient of the interface (as detected through geochemical, thermal, biologic activity, or other means). Monitoring for the POC shall use upland wells. The depth and location of the POC must take into account year-round variations in the groundwater-surface water interface.

Creek. This system will intercept impacted groundwater that would otherwise enter Railroad Creek and Copper Creek from the Lower West Area and Tailings Pile 1. Water collected from this system will be conveyed to a treatment facility.

During the second phase of remedy implementation, a second fully penetrating barrier wall and collection system will be constructed downgradient of Tailings Piles 2 and 3.

The period between the first and second phase presents an opportunity for Intalco to collect data in an effort to support a proposal to modify the second phase. The ROD allows for the collection of additional data following implementation of the first phase cleanup components, and includes the provision that the barrier wall design could be modified or would not need to be installed, if demonstrated to satisfy ARARs and be protective within a timeframe comparable to the Selected Remedy. The second phase of the remedy would not need to be installed only if it can be demonstrated to the Agencies' satisfaction that:

1. Groundwater concentrations are reduced to achieve surface water cleanup levels before that portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates; and

2. One of the following: a) groundwater meets MCLs below Tailings Piles 2 and 3, as well as throughout the plume; or b) groundwater that exceeds drinking water standards will be contained within a WMA; or c) an ARAR waiver for MCLs beneath Tailings Piles 2 and 3 based on technical impracticability from an engineering perspective is justified.

Such a change would require a ROD Amendment. The basis for the change must be demonstrated within 3 years of substantial completion of the first phase of remedial construction, so that a decision can be made in the fourth year. Unless the second phase groundwater barrier and collection system is eliminated, the second phase of remedial action is expected to be designed in the fifth year and constructed immediately thereafter.

12.2.3 Surface Water

Surface water will be addressed by preventing the erosion of tailings and stopping the discharge of contaminated runoff and groundwater (including seeps and discharge from the Main Portal) into surface water, including Railroad Creek,

Copper Creek, and the Copper Creek Diversion. The Selected Remedy includes the following actions to clean up surface water:

- Stabilizing the tailings pile slopes, contouring the tailings and waste rock piles to promote maximum runoff and reduce infiltration, diverting Railroad Creek away from the toes of the tailings piles, and modifying the Copper Creek Diversion and the Copper Creek channel to prevent release of tailings into surface water;

- Capturing and treating impacted groundwater from the Main Portal and Honeymoon Heights seeps; and

- Containing and treating impacted groundwater from the Lower West Area and Tailings Piles 1, 2, and 3.

Relocation of some portion(s) of Railroad Creek will enable construction of the groundwater barrier and collection system, and reduce the risk of slope instability from erosion or scour undermining the tailings piles slopes. The new channel will have an impervious liner where needed to prevent infiltration of clean water into contaminated groundwater that will be collected adjacent to the tailings piles.

The extent of stream relocation and tailings regrading will be assessed during remedial design. Although it would be possible to relocate a portion of Railroad Creek in each phase of remedial construction, the Selected Remedy requires creek relocation in a single construction effort in the first phase. A single-phase of creek relocation rather than two phases has the following advantages.

Relocation of Railroad Creek during the first phase of construction will:

- Reduce or eliminate the risk that regrading the slopes of Tailings Piles 2 and 3 would cause a release of tailings into the creek.

- Provide room for construction of a toe buttress and/or ground improvements adjacent to the toe of the tailings piles, which will be needed for stabilizing the regraded tailings pile slopes.

- Avoid the adverse effects of creek relocation of a second phase (e.g., sediment due to construction) on downstream aquatic life; and

- Reduce or avoid potential conflicts between a second-phase creek realignment and the new vehicle bridge and groundwater treatment plant near Tailings Pile 3.

Stormwater diversion swales and other measures will be constructed upgradient from Tailings Piles 1, 2, and 3 and the East and the West Waste Rock Piles, to control surface water run-on.

12.2.4 Sediment

The Selected Remedy will permanently relocate a portion of Railroad Creek to eliminate the effects of ferricrete on aquatic receptors and provide a natural channel substrate. The Selected Remedy also includes permanent containment of groundwater that has concentrations of iron and aluminum that produce floc in Railroad Creek to address this source of hazardous substances in creek sediment and the water column in the channel downstream of the mine.

Monitoring in Railroad Creek and at the Lucerne Bar in Lake Chelan along with bioassays based on the most current Agency protocols will determine whether the remedy is protective of sediment quality.

12.2.5 Other Remedial Components

The Selected Remedy also includes the following features:

- Construction of limited-purpose landfill(s) for disposal of remediation-derived waste.[30]

[30] Remediation-derived waste for the Holden Site cleanup is defined as: 1) tailings, waste rock, and soil impacted by tailings and/or waste rock that is excavated as part of the cleanup; 2) water treatment system sludge; 3) Holden Village's former municipal solid waste landfill and sewage treatment pond waste that may be encountered when regrading the tailings piles; 4) debris from existing structures that must be removed in order to allow for remedy implementation (such as structural steel and other materials from demolition of the Mill Building); and 5) other mine-related debris that will be disturbed as part of the remedy. The on-site waste disposal would need to satisfy ARARs for new waste disposal facilities (e.g., portions of the state's Limited Purpose Landfill requirements for location, design, construction, operation, closure, and monitoring, see WAC 173-350-400). For the Selected Remedy, as under Alternative 14, water treatment

- A groundwater treatment system as described in the final Feasibility Study.[31] Effluent from the treatment facility shall satisfy ARARs including the Biotic Ligand Model for copper, and may include a mixing zone approved in accordance with WAC 173-201A-400.[32] Chemical-specific ARARs for several contaminants of concern depend on the hardness of the receiving water. The surface water ARARs presented in Table 3 are based on a hardness value of 9 mg/L which represents historic measurements at background station RC-6. The assessment of compliance with these ARARs once the remedy has been implemented may include consideration of hardness conditions in the receiving water at that time.

- Development of remedy infrastructure, including quarry site(s), borrow pit(s), reconstruction of the Lucerne barge landing facility, construction work camp, and/or related infrastructure improvements at Holden Village, improvements to the Lucerne-Holden Road including bridges, electric power infrastructure, and other infrastructure, as needed. The Agencies consider development of hydroelectric power generating capacity to be highly desirable.

- Consolidation of tailings as encountered during construction in areas outside the main tailings piles, e.g., within the Wind-Blown Tailings Area, in the Lower West Area, and in the wetlands directly east of Tailings Pile 3.

---

system sludge would be disposed of in a lined on-site landfill designed and constructed for this purpose. The potential use of an unlined sludge disposal facility, possibly on the tailings piles (i.e., within a groundwater containment area) could be further evaluated during remedial design as proposed by Intalco for Alternative 13M. It will also be necessary to plan for future disposal of potentially contaminated soil that may be generated by future excavations in Holden Village and possibly other areas of the Site. This ROD does not allow disposal of Holden Village debris as remediation-derived waste on National Forest System lands (i.e., the debris on top of the West Waste Rock Pile).

[31] MTCA requires that the groundwater treatment system satisfy AKART, WAC 173-340-720(8)(d)(i). The approval of a mixing zone for the treatment facility effluent, or the possible development of site-specific water quality criteria through use of a water effects ratio, would first require satisfying AKART.

[32] Intalco has proposed and the Agencies are open to a Water Effects Ratio (WER) study that may result in modification of the cleanup levels. A change in the cleanup levels based on the WER would be implemented through a ROD Amendment.

- Temporary and/or permanent relocation of Holden Village infrastructure (e.g., portions of the potable water system, maintenance yard, and composting facility) as needed to enable remedial construction.

- Mitigation to address unavoidable adverse impacts of remedy construction such as, but not limited to, replacement of wetlands or floodplains that are filled, and revegetation of disturbed areas with native species to restore existing habitat.

- Sampling and analysis during remedial design to better define the extent of cleanup in areas such as the Lower West Area and the Ventilator Portal Surface Water Retention Area and to investigate the nature and extent of environmental impacts related to: a) potential waste rock on the Lucerne-Holden Road; and b) ore processing residuals in the former Mill Building area. The results of the investigation will be used to develop plans to consolidate and dispose or cap these wastes in place during remedial implementation.

- Institutional controls that would be implemented by the notation of restrictions in the Forest Service Land Status Records for the Okanogan-Wenatchee National Forest and through a restrictive covenant on private property owned by Holden Village. The institutional controls are anticipated to be needed in perpetuity, since hazardous substances will be left on the Site. The institutional controls would:

    1. Notify the public of contaminated areas that will be left on the Site, and prevent humans from direct contact with hazardous substances by warning of the risk;
    2. Protect the integrity of the remedy by preventing changes in site use that would reduce effectiveness of the remedy;
    3. Include a requirement for consultation with the Agencies prior to changes in land use to ensure the remedy remains protective;
    4. Require a soil management plan to address handling of soil with visible tailings that may be excavated in the future;
    5. Prevent potential future use of groundwater that exceeds human health risk-based criteria as a drinking water source, i.e., within WMAs;
    6. Provide for permanent access to privately owned land to monitor and maintain the remedy; and
    7. Implement possible administrative access restrictions to some portions of the Site.

- Long-term monitoring to assess remedy performance, ARAR compliance, and protectiveness.

12.2.6 Permits

CERCLA Section 121(e)(1) states that "no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site where such remedial action is selected and carried out in compliance with [Section 121]." 42 U.S.C. § 9621(e)(1). The term "on-site" is clarified in the NCP at 40 C.F.R. § 300.5, which states that "on-site means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action." The Agencies have determined that the Site includes the Railroad Creek valley from the Ballfield Area west of the Holden Mine to the area of contaminated Lake Chelan sediment at Lucerne. The Agencies will determine the substantive requirements that are to be met in lieu of permits that otherwise would be required for implementation of the remedy within this on-site area.

12.3 Summary of Estimated Remedy Costs

The Total Present Worth Cost of the Selected Remedy is approximately $107 million, as summarized in Table 23. The Agencies do not believe the changes made to Alternative 14 to create the Selected Remedy during the remedy selection process will significantly change the cost estimated in the ASFS.

The cost estimate presented in the ASFS is based on the best available information regarding the anticipated scope of the Selected Remedy. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to –30 percent of the actual project cost. Changes in the cost may arise as design is accomplished and/or as a result of new information that will be collected during the remedial design. Changes to the remedy will be documented in the form of a memorandum in the Administrative Record, an ESD, or a ROD Amendment.

12.4 Expected Outcome of the Selected Remedy

The expected outcome of the Selected Remedy is summarized below.

The tailings and waste rock caps will be regraded to achieve stability and capped and revegetated with native species to comply with ARARs and ensure environmental protectiveness.

Revegetation with native plant species will follow removal or capping of impacted soil in areas including the Lower West Area, and the Ventilator Portal Surface Water Retention Area and other areas disturbed by preparations for, or implementation of, the remedy. The goal of the revegetation is to restore native ecosystems appropriate for the Railroad Creek valley, as required under the Forest Plan and EPA guidance.[33]

The duration and effectiveness of *in situ* treatment cannot be predicted until completion of treatability studies, but the DSHH, affected portions of the Lower West Area and Wind-Blown Tailings area, and other similar areas will continue to support forest and wetlands, with reduced adverse impacts on terrestrial receptors. The Honeymoon Heights Waste Rock Piles will not be physically altered, but the adverse effects of hazardous substances will be remedied through *in situ* treatment.

The remedy will address the discharge of contaminated groundwater into Railroad Creek. This, along with eliminating the effects of ferricrete and stabilizing the tailings pile slopes, will enable Railroad Creek to once again support fish and other aquatic life. The beneficial effects of eliminating the discharge of groundwater containing hazardous substances will begin as soon as groundwater containment is completed.

The Selected Remedy will achieve RAOs. Together, the selected response actions are expected to contain and manage the sources of groundwater contamination and restore groundwater to meet MCLs at and beyond the boundaries of the WMAs and to meet levels protective of surface water beneficial uses prior to the groundwater-surface water interface (i.e., groundwater is expected to achieve cleanup levels protective of surface water before reaching that portion of the hyporheic zone that supports aquatic life, including fish spawning and benthic macroinvertebrates). These outcomes are expected to occur in a reasonable timeframe shortly after implementation,

---

[33] Herbicides may be used as appropriate to treat weed-infested staging, travel, and disturbed areas according to the Pacific Northwest Region Invasive Plant Program Environmental Impact Statement (EIS) (2003) and the Okanogan-Wenatchee National Forest Invasive Plant EIS when completed. All applicable standards and guidelines from the Pacific Northwest Region Invasive Plant Program EIS, and Okanogan-Wenatchee National Forest Best Management Practices and/or the Okanogan-Wenatchee National Forest Invasive Species EIS (when completed) will be used during herbicide treatments.

following completion of the groundwater containment barriers and other remedy components. The timing for completing *in situ* soil treatment will be determined based on treatability tests during remedial design and implementation. Implementation of the Selected Remedy will support the reasonably anticipated land, groundwater, and surface water uses at the Site, subject to the institutional controls (see Section 9.1.5).

12.5 National Historic Preservation Act

The National Historic Preservation Act (NHPA), 16 U.S.C. § 470 et seq., provides that federal agencies take into account the effect of proposed actions (undertakings) on areas included or eligible for inclusion in the National Register of Historic Places (National Register). 16 U.S.C. § 470f.

The National Register-eligible Holden Mine Historic District is defined by the following elements/features grouped by function and location:

- Holden Mine Underground Workings and Portals;
- Holden Mill and General Office/Shop Complex;
- Tailings and Waste Rock Piles;
- Honeymoon Heights Camp and Tram;
- Winston Family Camp/Town Site;
- Town site (Holden Village);
- Miscellaneous features and scattered debris in the area between the Holden Ball Field, Honeymoon Heights Camp, Holden Village Town site, Holden Mill, and Tenmile Creek; and
- Forest Road 8301 between Lucerne and Holden Mine.

Individually and collectively these features/elements contribute to the significance of the Historic District.

Based on their review of the April 2011 Section 106 report titled "Holden Mine CERCLA Remediation Section 106 Consultation in Response to Alternatives 11, 13 and 14, Chelan Ranger District, Okanogan-Wenatchee National Forest,

Chelan County, Washington" the Agencies and the Washington State Historic Preservation Officer (SHPO) have determined and concur that the Selected Remedy will have an adverse effect on the Holden Mine Historic District because National Register-eligible historic mining features/elements will be removed or demolished and the landscape of the mine will be altered. Groups of affected historic features/elements are as follows:

1. Tailings Piles 1, 2, and 3, and the West and East Waste Rock Piles adjacent to the mill;

2. Holden Mill, office complex, and A-frame garage located in the Maintenance Yard below the Holden Mill;

3. Miscellaneous mining features and debris/artifacts located in the Lower West Area, Ballfield Area, Holden Village, and in the Wind-Blown Tailings Area east of Tailings Pile 3; and

4. The abandoned Holden septic system north of Railroad Creek and Forest Service Site 02-27.

The area of greatest impact will be south of Railroad Creek. The Selected Remedy will affect tailings, all or some of the waste rock piles, the Holden Mill and its associated office/shop complex, and the Maintenance Yard below the mill. Virtually all physical manifestations of the mine, with the exception of Honeymoon Heights Camp and the Honeymoon Heights tram, will be removed or capped creating an altogether different landscape south of the creek. The visual appearance of the Wind-Blown Tailings Area north of Railroad Creek will likely be changed as well. Portions of the abandoned Holden septic system (part of the Historic District) and the scarred trees documented as Site 02-27 will likely be removed by relocation of Railroad Creek or by treatment of wind-blown tailings in the same area.

Currently, the following groups of components of the Holden Mine Historic District will not be physically impacted:

1. Honeymoon Heights, Winston, and Holden camp/town sites; and

2. Forest Service sites 02-130 (Holden Guard Station) and 02-131 (45CH820) (Winston Peeled Cedars) located within the boundary of the Holden Mine Historic District will be avoided.

Forest Service Site 06170200027 is also located within the boundary of the Historic District, but as the site is not eligible for the National Register, it need not be avoided.

Substantively the NHPA regulations provide that an undertaking will evaluate and include "ways to avoid, minimize, or mitigate adverse effects" 36 C.F.R. § 800.6(b).

Appendix A of Part 2 of this ROD includes the Selected Remedy measures to avoid, minimize, or mitigate adverse effects to National Register-eligible sites located within the Selected Remedy area of potential effect.

13.0 STATUTORY DETERMINATIONS

13.1 Protection of Human Health and the Environment

The Selected Remedy will protect human health using engineering controls (consolidation and capping) for impacted soil that exceeds human health-based criteria for direct contact and ingestion in the Lower West Area, Lagoon Area, and Maintenance Yard, and institutional controls for waste rock and impacted soil on Honeymoon Heights.

The Selected Remedy will protect human health from exposure to contaminated groundwater by ensuring groundwater at and beyond the edge of the WMA meets drinking water standards and by institutional controls that prevent using groundwater contained within the WMA as drinking water.

The Selected Remedy will protect terrestrial environmental receptors from soil that exceeds cleanup levels through a combination of engineering controls (consolidation and capping) and *in situ* treatment. The Selected Remedy will protect aquatic environmental receptors through a combination of engineering controls, including containment, collection, and treatment of impacted groundwater that will otherwise discharge into Railroad Creek; stabilization of the tailings pile slopes and protection from erosion and scour; and by eliminating ferricrete from aquatic habitat. Monitoring will follow source controls to confirm that risks are low and decrease over time.

Consistent with the RAOs, opportunities will be sought during the implementation of the remedy to reduce its environmental footprint as defined in U.S. EPA Office of Solid Waste and Emergency Response Principles for Greener Cleanups and EPA Region 10's August 2009 Clean and Green Policy.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The Selected Remedy for the Site will comply with federal and state ARARs that have been identified. The Selected Remedy will contain soil and groundwater exceeding cleanup levels within WMAs on the Site. Groundwater within the WMAs on the Site will not be returned to beneficial use; however, groundwater and surface water at and beyond the boundaries of the WMAs will be restored to beneficial use and achieve ARARs under the Selected Remedy. Tables 16 through 19 provide a complete list of ARARs and TBCs that must be addressed by the Selected Remedy and a comparison of how Alternatives 11M, 13M, and 14 would address each of these ARARs.

13.3 Cost-Effectiveness

In the Agencies' judgment, the Selected Remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." 40 C.F.R. § 300.430(f)(1)(ii)(D). This was accomplished by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment, and ARAR-compliant), as well as comparison to Alternative 13M that did not satisfy the threshold criteria.

The Selected Remedy is, overall, more cost-effective than any of the other alternatives considered since it provides better long-term effectiveness and permanence, along with a greater degree of certainty that it will be successful.

As discussed in Section 10.3, the Selected Remedy (based on Alternative 14) has less risk remaining from the untreated waste or treatment residuals remaining at the conclusion of the remedial activities since it includes treatment of soil that is not treated under Alternative 13M and provides for a greater degree of groundwater containment, collection, and treatment.

The Selected Remedy is less costly than Alternative 11M, but provides substantially the same degree of environmental risk reduction. Although removal of waste rock and impacted soil from Honeymoon Heights would produce more certain benefits than *in situ* treatment, this benefit would be gained at the cost of substantially greater adverse environmental impacts compared to the Selected Remedy.

The Selected Remedy also is more reliable than Alternative 11M, since it does not rely on the membrane liner system used in the Alternative 11M tailings and waste rock pile caps that would be difficult to maintain and repair.

The alternatives evaluated have similar uncertainties associated with: a) land disposal of treatment system residuals: b) the potential need to replace technical components of the remedy (except the geomembrane liner referred to above); and c) potential risk if components of the remedy need replacement. As discussed in the ASFS, there will be a similarly low risk to human health and the environment, compared with existing conditions, should remedy components fail or need to be replaced under Alternatives 11M, and 13M, and the Selected Remedy.

Overall cost-effectiveness also includes the degree to which the Selected Remedy employs treatment to reduce toxicity, mobility, or volume compared to other alternatives. Alternatives 11M, 13M, and 14 use similar treatment technology to remove hazardous substances from groundwater and immobilize these substances in sludge contained in an on-site landfill, following treatment of intercepted groundwater. The Selected Remedy, similar to Alternative 11M, will prevent migration of hazardous substances in groundwater from all known source areas. Alternative 13M would not prevent migration of hazardous substances in groundwater under Tailings Piles 2 and 3 and contaminated groundwater would continue to discharge to Railroad Creek.

Overall cost-effectiveness also includes the short-term effectiveness of the Selected Remedy Evaluation. As discussed in Section 10.1.2, the Selected Remedy has similar short-term risks to the community, potential impacts to workers during remedial construction, and environmental impacts of the remedial action compared to the other alternatives. The main difference is that construction of the Selected Remedy will take longer and involve more construction compared to Alternative 13M. However, this is because Alternative 13M would not be as protective of the environment as the Selected Remedy, and the Selected Remedy will achieve protection more rapidly than Alternative 13M.

Because the Selected Remedy will be accomplished in two phases, it will take longer to complete than Alternative 11M. However, neglecting the 5-year break between the first and second phases of construction, the Selected Remedy is expected to require less actual construction time compared to Alternative 11M because of the elimination of the geomembrane and removal actions on Honeymoon Heights.

13.4 Use of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

The Agencies have determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, the Agencies have determined that the Selected Remedy provides the best balance of tradeoffs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal, and considering state and community acceptance.

The NCP balancing criteria in selecting a remedy include: 1) long-term effectiveness and permanence; 2) reduction of toxicity, mobility, or volume through treatment; 3) short-term effectiveness; 4) implementability; and 5) cost. The Selected Remedy achieves these criteria as summarized below, and as more fully discussed in Section 10.1.2 of this ROD.

Engineering controls employed in the Selected Remedy, including removal and containment, are appropriate as a permanent remedy for soil at the Site because this soil can be reliably controlled in place.

The Selected Remedy achieves the statutory preference for long-term reduction of toxicity and mobility of hazardous substances with treatment as a principal element.

The Selected Remedy includes containment, collection, and treatment of groundwater above cleanup levels (using pH adjustment and precipitation to remove hazardous substances) that would otherwise discharge into surface water. This is an established form of engineering controls that has been demonstrated at a number of other sites (as described in the final Feasibility Study). Capping the tailings piles and the main waste rock piles, and containment, collection, and treatment of impacted groundwater are the most permanent solutions that are practicable at the Site.

In situ treatment, while less proven than consolidation and capping, can be accomplished with less adverse environmental impact and, therefore, is identified for some areas of the Site, including the small waste rock piles on Honeymoon Heights and other specified areas where impacted soil will be left in place. This treatment, using pH adjustment to reduce the mobility and toxicity

of hazardous substances, is also a permanent solution for those specific areas of the Site.

The Selected Remedy's engineering controls provide for long-term effectiveness and permanence, achieve short-term effectiveness, and are implementable.

As described in Section 12, the overall effectiveness of the Selected Remedy was determined to be proportional to its costs and, hence, the Selected Remedy is cost-effective.

13.5 Preference for Treatment as a Principal Element[34]

The Selected Remedy includes treatment of both groundwater and some impacted soil, which satisfies the statutory preference for treatment.

The NCP also established an expectation for use of engineering controls such as containment for waste that poses a relatively low, long-term threat or where treatment is impracticable (40 C.F.R. 300.430(a)(1)(iii)(B)). Engineering controls, including consolidation and containment (capping), are employed for most soil in the Selected Remedy.

The Selected Remedy fully addresses the statutory preference for permanence and treatment to the maximum extent practicable.

13.6 Five-Year Review Requirements

Because the Selected Remedy will result in hazardous substances remaining on the Site above levels that allow for unlimited use and unrestricted exposure, statutory reviews will be conducted at least every 5 years after initiation of the remedial action to ensure that the Selected Remedy is, or will be, protective of human health and the environment.

[34] The NCP establishes an expectation for the use of treatment to address the principal threats posed by a site wherever practicable [40 C.F.R. 300.430(a)(1)(iii)(A)]; however, no Principal Threat Wastes were identified on Site.

14.0 DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PREFERRED ALTERNATIVE IN THE PROPOSED PLAN

The Proposed Plan was released for public comment on June 23, 2010. The Proposed Plan identified Alternative 14 as the Preferred Alternative. The Agencies reviewed the written and verbal comments submitted during the public comment period, and determined that no significant changes to the remedy, as originally identified in the Proposed Plan, are necessary or appropriate. The Selected Remedy contains minor changes from the Preferred Alternative identified in the Proposed Plan, as summarized below. Modification of the Preferred Alternative to create the Selected Remedy in response to comments is, consistent with the NCP [40 C.F.R. § 300.430(f)(4)(i)].

1. Final selection of the number and location of groundwater treatment facilities will be determined during remedial design, based on the results of approved engineering studies. The final Feasibility Study included evaluation of two separate groundwater treatment facilities (i.e., in the Lagoon Area, and south of Railroad Creek and east of Tailings Pile 3) that could be operated independently or in series (i.e., with one location providing pretreatment for a portion of the groundwater); as well as a single treatment facility located northeast of Tailings Pile 3. The final Feasibility Study indicated there are a number of tradeoffs with different treatment system configurations that will need to be evaluated during remedial design.

2. Final design of tailings and waste rock pile slopes, including a stabilizing buttress or ground improvement, and the extent of creek relocation will be determined during remedial design, based on the results of approved engineering studies. Ferricrete removal will be required where present in reaches of the creek that are not relocated.

3. Remediation of impacted soil in the Ventilator Portal Surface Water Retention Area, Lower West Area, and the Maintenance Yard, involving either capping in place, *in situ* treatment, and/or consolidating the impacted soil into the tailings piles before capping, or some combination of these approaches, will be determined during remedial design, based on the results of approved engineering studies.

4. Although ARAR waivers were discussed in the Proposed Plan for groundwater quality within the WMAs, the Agencies have determined for this ROD that waivers are not required.

5. Surface water cleanup levels were modified slightly from those presented in the Proposed Plan. These modifications represent changes in background water quality and hardness values that reflect additional data collected by Intalco since the Proposed Plan.

6. Additional evaluations of terrestrial ecological risks were conducted for several AOIs; these evaluations were prompted by comments received on the Proposed Plan. The additional evaluations looked at tissue concentrations (plants and invertebrates) in relation to tissue-based toxicity values and tissue concentrations in background areas. They also looked at soil pH and its effect on the toxicity of aluminum. As a result, some constituents were eliminated as contaminants of concern for the terrestrial ecological pathway. At the Wind-blown Tailings Area, the contaminants of concern previously identified in the Proposed Plan were eliminated, resulting in a change in the Selected Remedy compared to the Preferred Alternative for this AOI from *in situ* soil treatment to no action except where visible tailings are encountered during remedy construction and/or in the event of future changes in land use or ground disturbance.

7. The Selected Remedy also differs from the Preferred Alternative for the Ballfield Area. The remedy was changed from *in situ* soil treatment, as presented in the Proposed Plan, to a combination of hot spot investigation/removal along with possible *in situ* treatment. This modification resulted from the additional ecological risk evaluations described above in Item 6 along with further evaluation of the spatial distribution of contaminants and historical data (i.e., the possible presence of an old haul road).

8. The Proposed Plan called for consolidation of tailings encountered during construction in areas outside the main tailings piles, including within the Wind-blown Tailings Area and in the Lower West Area, and consolidation of these materials on the tailings piles. The Selected Remedy presented in this ROD also calls for tailings encountered in the wetlands directly east of Tailings Pile 3 to be removed and consolidated. This change reflects the observation of tailings in the wetlands during early action construction activities and the possibility that such tailings may not be otherwise be removed during construction of the water treatment plant, since the location of the treatment plant may not be in this area (as was envisioned in the Proposed Plan).

9. The WMA boundaries for the Selected Remedy were redrawn from those shown in the Proposed Plan to combine several adjacent areas. These changes were made to more accurately reflect the indistinguishable impacts from these adjacent areas on underlying groundwater quality.

10. The ROD includes a requirement for future sediment monitoring using bioassays, based on scientific information that was not available at the time of the Proposed Plan (Ecology 2011).

11. The point of compliance discussion was further clarified with respect to groundwater MCLs and surface water cleanup standards (groundwater to surface water discharge).

15.0 REFERENCES

Boulton et al. 1998. The Functional Significance of the Hyporheic Zone in Streams and Rivers. Annual Review of Ecology and Systematics. 1998.

Cubbage, J., D. Batts, and J. Breidenbach 1997. Creation and Analysis of Freshwater Sediment Quality Values in Washington State, Washington State Department of Ecology Publication No. 97-323A.

Dames and Moore 1999. Draft Final Remediation Investigation Report, Holden Mine Site. July 28, 1999. Prepared for Alumet, Inc.

Ecology 2007. Model Toxics Control Act - Cleanup (Chapter 173-340 WAC). Revised November 2007.

Ecology 1997. Effects of Holden Mine on the Water, Sediments, and Benthic Invertebrates of Railroad Creek (Lake Chelan). Washington State Department of Ecology. Publication No. 97-330. July 1997.

Ecology 2008a. Water Quality Program Permit Writer's Manual. Publication No. 92-109.

Ecology 2008b. Water Quality Program Criteria for Sewage Works Design. Publication No. 98-37.

Ecology 2010. Water Quality Program Permit Writer's Manual. Publication No. 92-109. Revised November 2010.

Ecology 2011. Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho. Washington State Department of Ecology Publication No. 11-09-05. Dated November 2011.

EPA 2000. EPA Guidance: A Guide to Developing and Documenting Cost Estimates during the Feasibility Study. July 2000.

EPA 2004a. An Examination of EPA Risk Assessment Principles and Practices. EPA/100/B-04/001. March 2004.

EPA 2004b. Region 9 Preliminary Goals Table. October 2004.

EPA 2009. Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration. OSWER Directive 9283.1-33, dated June 26, 2009.

ERM 2008. TEE Field Investigation Data Report, Holden Mine Site, Chelan County, Washington. November 12, 2008.

ERM 2009a. Draft Terrestrial Ecological Evaluation Report, Holden Mine Site, Chelan County, Washington. March 2009. Prepared for Intalco.

ERM 2009b. Draft Proposed Alternative Toxicity Reference Values for Copper, Thallium and Aluminum, in Support of the Terrestrial Ecological Evaluations, Holden Mine Site, Chelan County, Washington. Prepared for Intalco. September 2009.

ERM 2009c. Draft Proposed Alternative Toxicity Reference Values for Lead, Mercury, Molybdenum, and Zinc in Support of the Terrestrial Ecological Evaluations, Holden Mine Site, Chelan County, Washington. Prepared for Intalco. November 2009.

ERM 2010a. Terrestrial Ecological Evaluations Summary, Holden Mine Site, Chelan County, Washington. January 2010.

ERM 2010b. Draft Tailings and Waste Rock Pile Cover Evaluation and Selection, Holden Mine Site, Chelan County, Washington. January 2010.

ERM and URS 2009. Draft Alternative 13M Evaluation Report, Holden Mine Site, Chelan County, Washington. August 14, 2009.

Forest Service 1940. Forest Surface Road Resurfacing Memo. W.O. Shambaugh, District Ranger. Prepared for Howe Sound Company. April 24, 1940.

Forest Service 1999. Holden Mine Remedial Action Objectives. Norman F. Day, Forest Service. Prepared for David E. Jackson & Associates, Inc. February 26, 1999.

Forest Service 2000. Agencies' Detailed Comments on the Holden Mine Draft Remedial Investigation Report dated July 29, 1999. February 1, 2000. Norman F. Day, Forest Service. Prepared for David E. Jackson & Associates, Inc.

Forest Service 2002a. Finalization of Holden Mine Remedial Investigation Report. Norman F. Day, Forest Service. Prepared for David E. Jackson & Associates, Inc. February 8, 2002.

Forest Service 2002b. Agencies' Detailed Comments on the Holden Mine Draft Feasibility Study dated June 12, 2002. Norman F. Day, Forest Service. Prepared for David E. Jackson & Associates, Inc. July 26, 2002.

Forest Service 2003. Comments on Intalco's Response to Agency Comments Regarding ARARs, dated January 22, 2003. March 6, 2003. Norman F. Day, Forest Service. Prepared for David E. Jackson & Associates, Inc.

Forest Service 2007a. Agencies' Comments on the Draft Final Feasibility Study. August 31, 2007. Prepared for Intalco.

Forest Service 2007b. Supplemental Feasibility Study, Holden Mine Site, Chelan County, Washington. September 2007.

Forest Service 2007c. Agencies' Comments on Intalco's Alternative 9 Description. Prepared for Intalco. August 31, 2007.

Forest Service 2007d. RE: Completion of the Feasibility Study for the Holden Mine Site. Prepared for Theodore L. Garrett, Covington & Burling, Counsel to Alumet (Intalco). September 13, 2007.

Forest Service 2010a. Addendum to the Supplemental Feasibility Study, Holden Mine Site, Chelan County, Washington. June 1, 2010.

Forest Service 2010b. Agencies' Comments on Intalco's August 14, 2009, Alternative 13M Evaluation Report. June 1, 2010.

Forest Service 2010c. Proposed Plan, Holden Mine Site, Chelan County, Washington. June 1, 2010.

Garrett, Theodore L. 2005. Holden Mine Remedial Alternative 9, Alternative 9 Description and Focused CERCLA-MTCA Feasibility Evaluation, Holden Mine Site, Chelan County, Washington. Covington & Burling, Counsel to Alumet (Covington and Burling). November 18, 2005.

Garrett, Theodore L. 2007. RE: Holden Mine: Submission of Alternative 13. Covington & Burling, Counsel to Alumet (Covington and Burling). October 15, 2007.

Gensemer, R.W. and R.C. Playle 1999. The Bioavailability and Toxicity of Aluminum in Aquatic Environments. Critical Reviews in Environmental Science and Technology, 29(4), 315-450, 1999.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York.

Hart Crowser 2005. Holden Mine Site, Chelan County, Washington, Site Information Package. Prepared for USEPA National Remedy Review Board. September 1, 2005.

Ingersoll et al. 1996. Calculation and Evaluation of Sediment Effect Concentration for the Amphipod Hyalella azteca and the Midge Chironomus riparius. Journal of Great Lakes Research. 22(3):602-623.

Lappivaara et al. 1999. A Bioaccumulation and Subchronic Physiological Effects of Waterborne Iron Overload on Whitefish Exposed in Humic and Nonhumic Water. Archives of Environmental Contamination and Toxicology. 37: 196-204.

Michelsen, T. 2003. Development of Freshwater Sediment Quality Values for Use in Washington State. Phase II Report: Development and Recommendation of SQVs for Freshwater Sediments in Washington State. Avocet Consulting. September 2003.

Pacific Northwest Laboratory 1992. Draft Holden Mine Reclamation Project - Final Report. Contract DE-AC06-76RLO 1830.

Persaud et al. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy. ISBM 0-7729-9248-7.

Steffen, Robertson, and Kirsten, Inc. (SRK) 2003. Results of Humidity Cell Testing on Tailings – Holden Mine. Steffen, Robertson, and Kirsten (Canada), Inc. July 2003.

Stratus 2005. HEA Calculations for the Holden Mine Site, Chelan County, North Central Washington State. Prepared for Forest Service. April 15, 2005.

URS 2001a. Holden Mine November 2000 Underground Investigation Data Transmittal. Jennifer Deters, URS. Prepared for Norman Day, Forest Service. January 24, 2001.

URS 2001b. Holden Mine Spring 2001 Underground Investigation Data Transmittal. Jennifer Deters, URS. Prepared for Norman Day, Forest Service. August 28, 2001.

URS 2002a. Holden Mine Fall 2001 Hydrogeologic Investigation Project Plans, Response to Agency Comments. Jennifer Deters, URS. Prepared for Norman Day, Forest Service. November 6, 2001.

URS 2002b. Fall 2001 Geotechnical/Geochemical Investigation Data Transmittal, Holden Mine RI/FS. URS Corporation. April 1, 2002.

URS 2002c. Fall 2001 Lake Chelan Sediment Sampling Data Transmittal, Holden Mine RI/FS. URS Corporation. April 1, 2002.

URS 2002d. Draft Feasibility Study, Holden Mine Site. Prepared by URS Corporation for Intalco. June 12, 2002.

URS 2002e. Spring 2002 Hydrogeologic Investigation Data Transmittal Holden Mine RI/FS. Jennifer Deters, URS. Prepared for Norman Day, Forest Service. September 16, 2002.

URS 2002f. Summer 2002 Groundwater Level Data Transmittal Downgradient Groundwater Monitoring Wells, Holden Mine RI/FS. URS Corporation.

URS 2003a. Final Monitoring Report, Bat Monitoring and Winter Survey of Underground Mine Workings, Holden Mine RI/FS. URS Corporation. February 11, 2003.

URS 2003b. Fall 2002 Hydrogeologic Investigation Data Transmittal, Holden Mine RI/FS. URS Corporation. February 5, 2003.

URS 2003c. Fall 2002 Lake Chelan Sediment Sampling Data Transmittal, Holden Mine RI/FS. URS Corporation. May 5, 2003.

URS 2003d. Spring 2003 Surface Water Monitoring Data Transmittal, Holden Mine RI/FS. URS Corporation. October 23, 2003.

URS 2004. Draft Final Feasibility Study, Holden Mine Site. URS Corporation. February 19, 2004.

URS 2005. Alternative 9 Description and Focused CERCLA-MTCA Feasibility Evaluation, Holden Mine Site, Chelan County, Washington. URS Corporation. Prepared for Intalco Aluminum Co. November 17, 2005.

URS 2006. Holden Mine, Spring 2006 Field Effort, Data Transmittal. URS Corporation. Prepared for Intalco. December 22, 2006.

URS 2008. Holden Mine 2008 Field Investigation Data Compilation Report. November 7, 2008. URS Corporation.

URS 2009a. Appendix F: Draft Supplemental Human Health Risk Evaluation for the Tailings and Waste Rock Piles. URS Corporation. July 10, 2009.

URS 2009b. Fall 2009 Additional Sampling Recommendations. URS Corporation. October 13, 2009.

URS 2010. Draft Hydrogeology Technical Memorandum Addendum in Context of a Contingent Remedy Holden Mine Site. URS Corporation. February 24, 2010.

USACE et al. 2006. Sediment Evaluation Framework for the Pacific Northwest - Interim Final. Prepared by the US Army Corps of Engineers - Seattle District, Portland District, Walla Walla District, and Northwestern Division; Environmental Protection Agency Region 10; Washington State Department of Ecology; Washington Department of Natural Resources; Oregon Department of

Environmental Quality; Idaho Department of Environmental Quality; National Marine Fisheries Service; and US Fish and Wildlife Service 2006. September 2006.

USDA Office of General Counsel (USDA OGC) 2006. Holden Mine, Iron and Aluminum as Hazardous Substances. Prepared by James Alexander for Intalco. April 7, 2006.

USDA Office of General Counsel (USDA OGC) 2008. Holden Mine - Modification of AOC Work and Proposed Plan Deferral. Prepared by James Alexander for Intalco. March 11, 2008.

USFWS 2004. Tables of Published Toxicity Values at Water Hardness Concentrations Similar to Railroad Creek. June 16, 2004.

USFWS 2005. Aluminum and Iron Toxicity Related to Water Quality Parameters Similar to Railroad Creek. January 3, 2005.

USFWS 2007a. Response to Intalco's June 17, 2005, Comments on Potential for Impacts to Aquatic Life in Railroad Creek from Copper, Cadmium, Zinc, Aluminum, and Iron, Final Agency Response. James A. Hansen, PhD. Prepared for Holden Mine Remedial Action Agencies. August 27, 2007.

USFWS 2009. Additional Request for Information (USFS No: 2160/2800). Ken S. Berg, Washington Fish and Wildlife Office. Prepared for Norman Day, US Forest Service. July 15, 2009.

USGS 2011. USGS Surface-Water Data for Washington. Gage #12451500 Railroad Creek at Lucerne, Washington. http://waterdata.usgs.gov/wa/nwis/sw. Data accessed March 21, 2011.

Wilkin, Richard T. 2007. Metal Attenuation Processes at Mining Sites. Groundwater and Ecosystem Restoration Division of the National Risk Management Research Lab. Published by EPA. September 2007.

L:\Jobs\476916\ROD\Holden ROD Final January 2012.doc